SAE JOURNAL

AUGUST
1953

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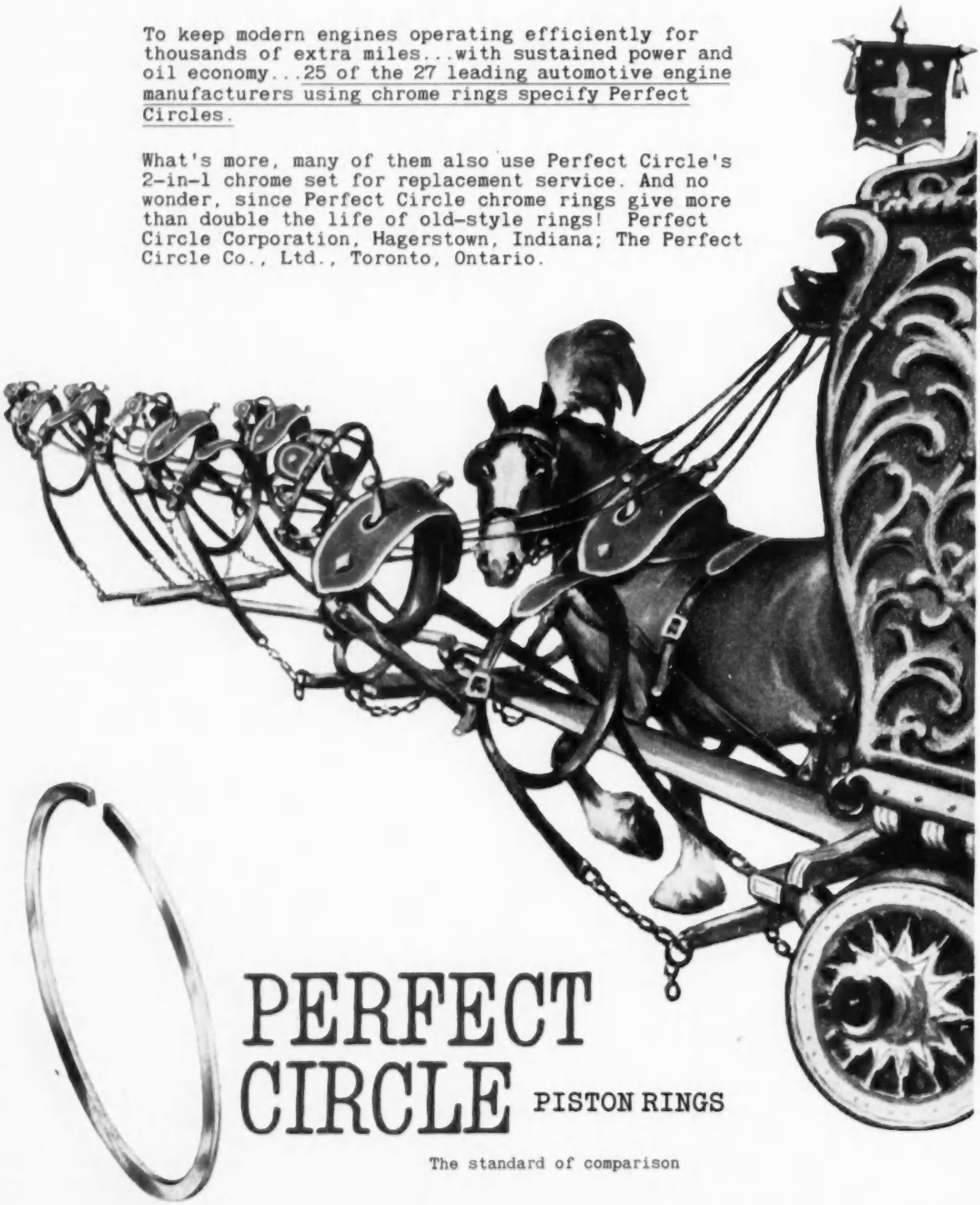

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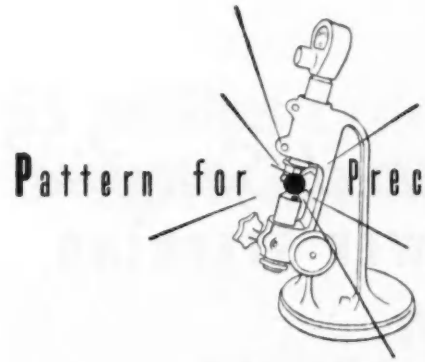

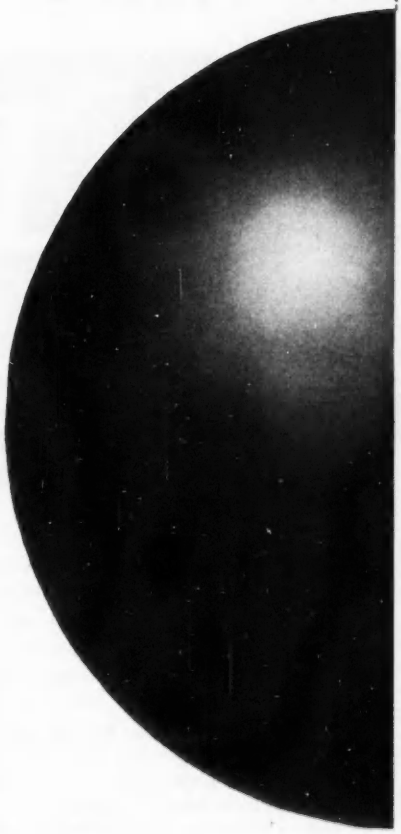

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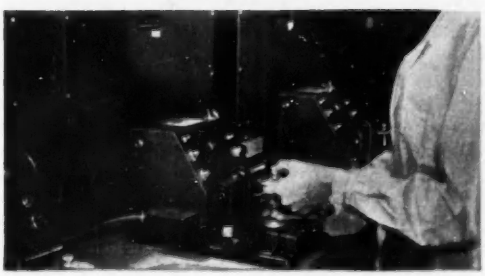

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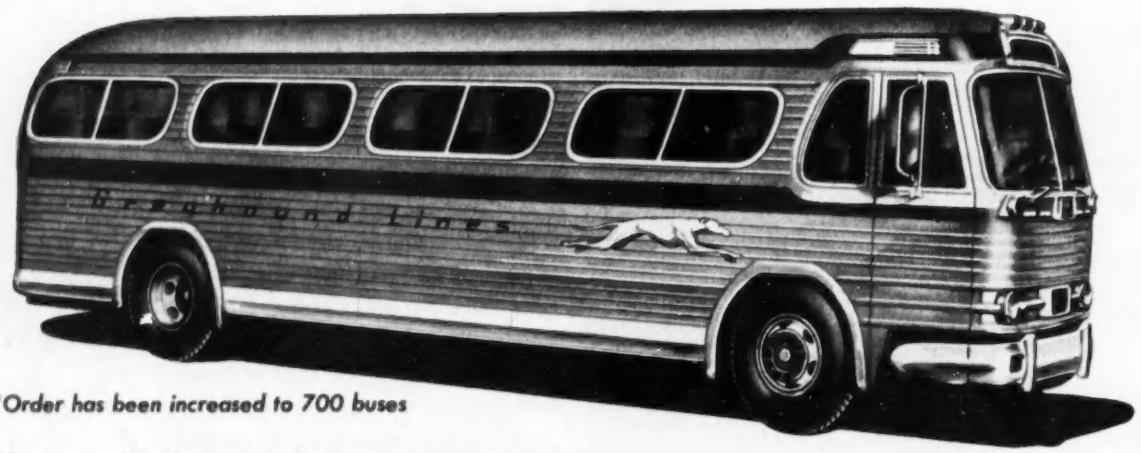

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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

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55 million cycles and this 4-way valve is still going strong!

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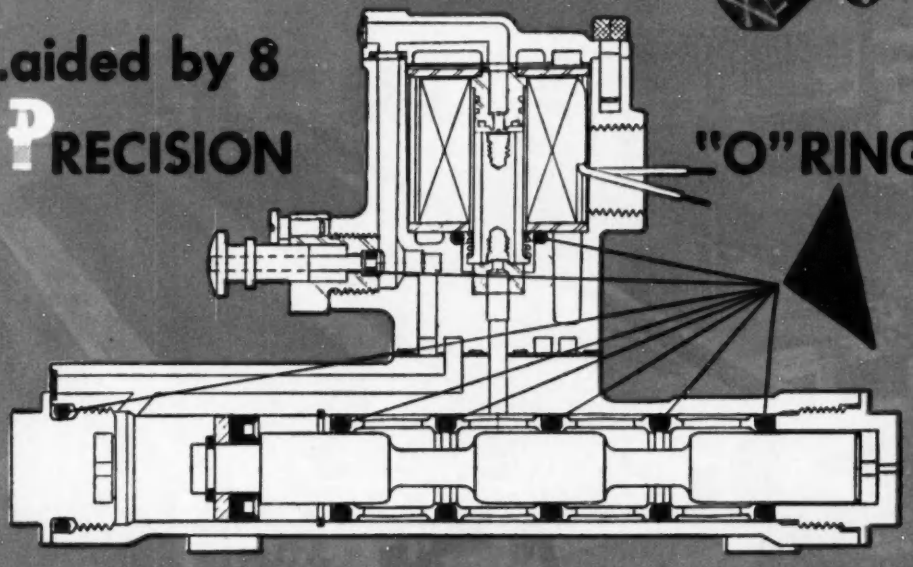

This pilot-operated 4-way valve—developed by THE VALVAIR CORPORATION of Akron, Ohio—employs 8 *Precision* "O" Rings for leak-proof sealing under air, oil, water or inert gas pressure. Designed to give trouble-free performance for more than 50 million cycles of heavy-duty service, this compact valve requires "O" Rings of *highest quality*—and that is why *Precision* "O" Rings were chosen!

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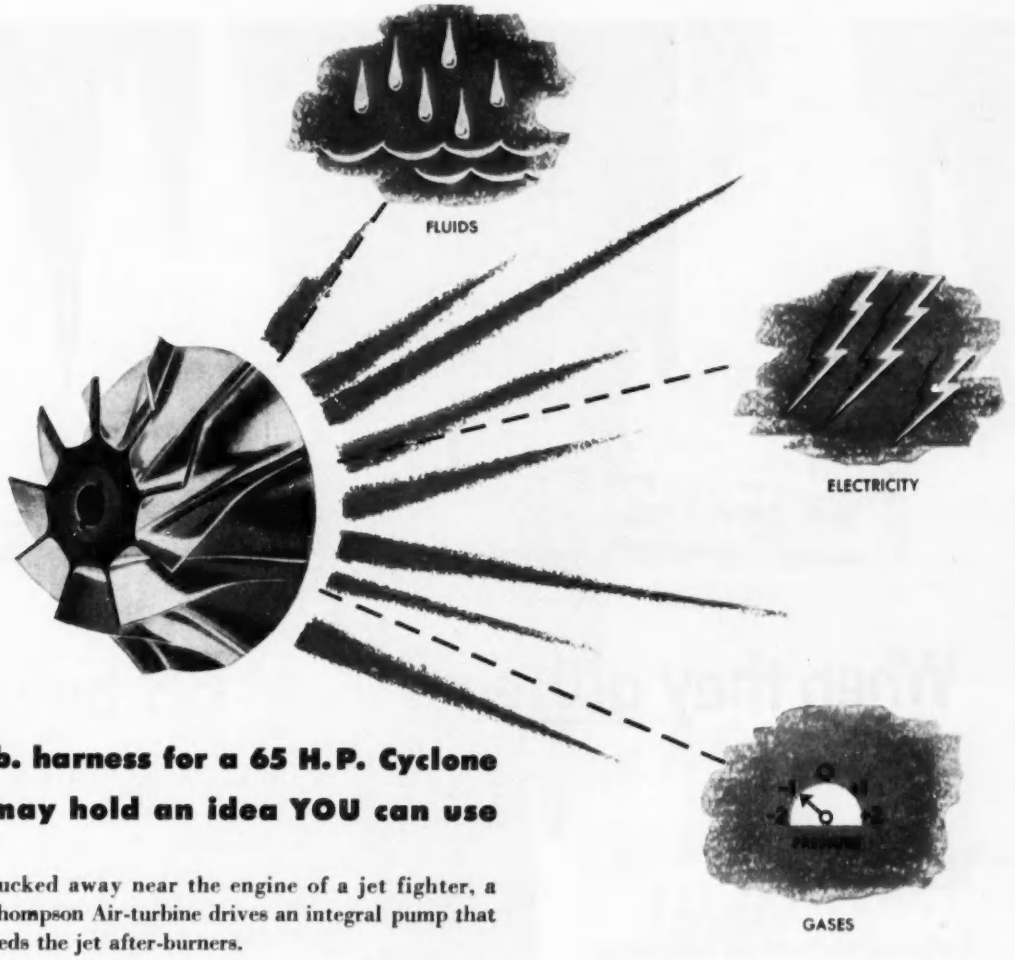

This 12 lb. harness for a 65 H.P. Cyclone ...may hold an idea YOU can use

Tucked away near the engine of a jet fighter, a Thompson Air-turbine drives an integral pump that feeds the jet after-burners.

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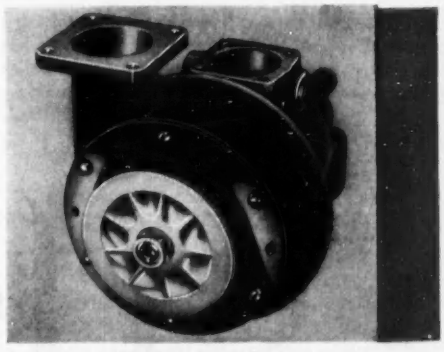
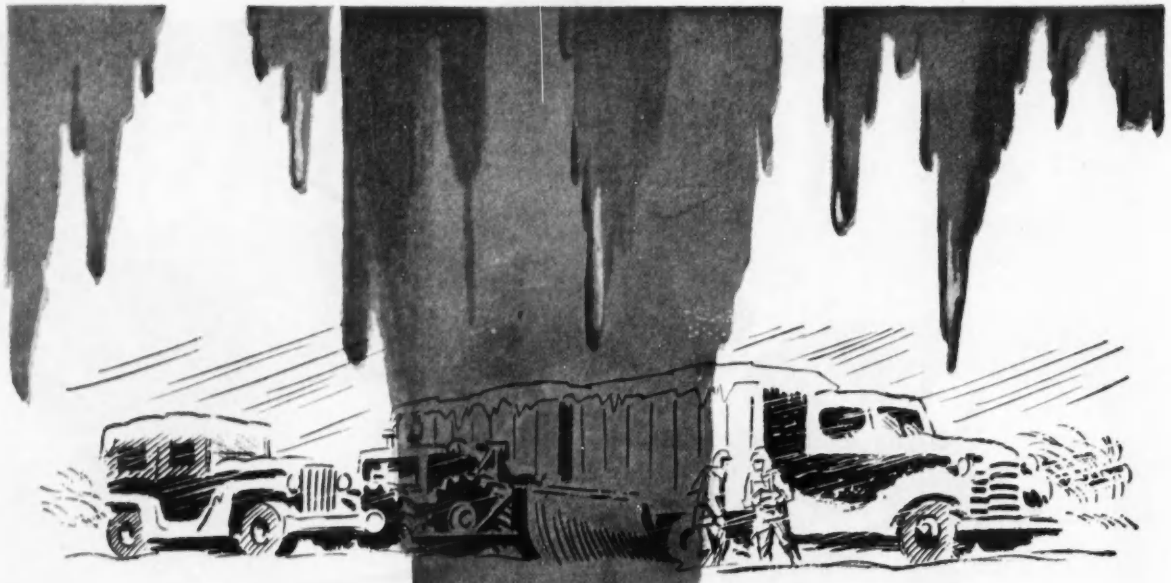


12-pound, 65-HP Air-Turbine-driven Pump



When they gotta go ... at 65° below!

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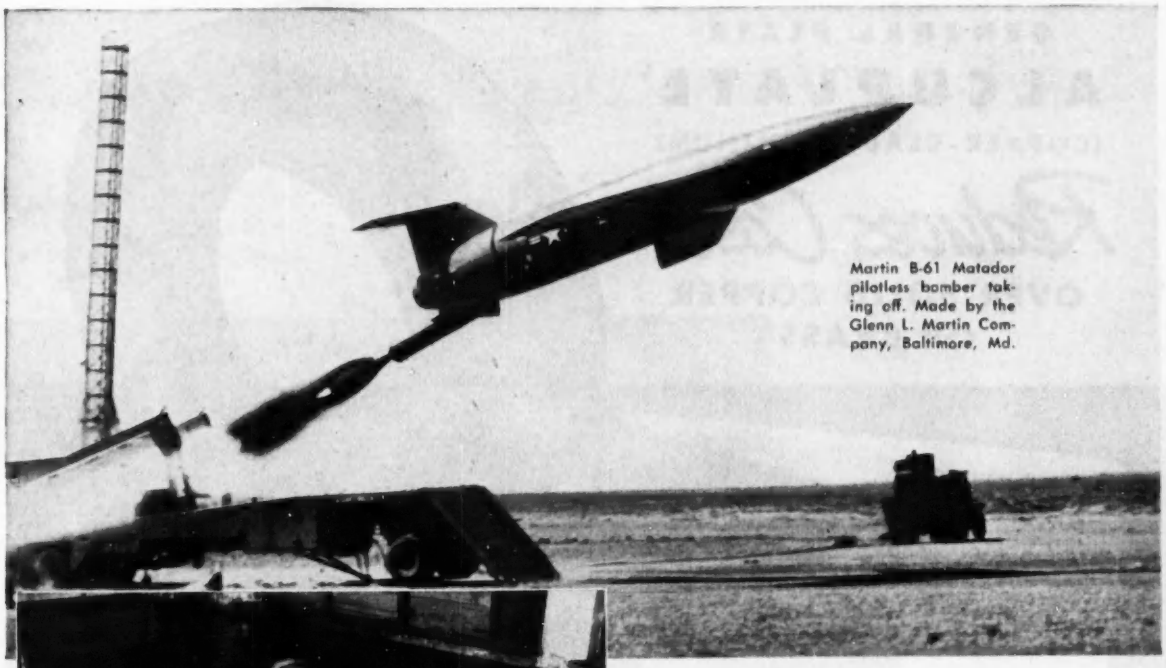
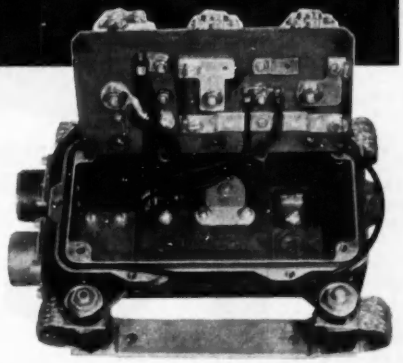


Martin B-61 Matador pilotless bomber taking off. Made by the Glenn L. Martin Company, Baltimore, Md.

Jeep almost completely submerged. Can be operated in this position at about 9 miles per hour. Made by Willys-Overland Motors, Inc., Toledo, Ohio, for the Armed Forces.



Generator regulator for the 24-volt system of the submersible Jeep. This is completely waterproof and highly resistant to corrosion and fungi. Produced by The Electric Auto-Lite Company, Toledo, Ohio.

Illustrated are two of the many types of capacitors and filters made by Aerovox Corporation, New Bedford, Mass.; an important capacitor supplier to both Electric Auto-Lite and Glenn L. Martin. The unit above is the filter capacitor used in the generator regulator of the submersible jeep while the unit at the right is used in the pilotless bomber.

In the Air— On Land— Under Water—

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The dramatic pictures on this page show two important special applications of Aerovox capacitors. One is the Martin B-61 Matador pilotless bomber. It contains an Aerovox capacitor, which has to withstand the terrific acceleration and speed of the craft. The other is the submersible Jeep. Its 24-volt electrical system is completely waterproofed, and includes Aerovox filters and capacitors for suppression of radio interference. Revere not only supplied copper and brass strip for the capacitor cases, but collaborated closely in setting up specifications, and in addition worked on a welding problem. In regard to the latter, an Aerovox Project Engineer wrote: "We have had much better welds." . . . Revere is always glad to collaborate on problems concerning copper and its alloys, aluminum alloys, and electric welded steel tube. Call the nearest Revere Sales Office.

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COMPONENT CASES—ALCUPLATE is successfully drawn and formed into lightweight cases or cans and intricate parts.

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ELECTRICAL TERMINALS — Small terminals and large pressure-type connectors use single-clad ALCUPLATE . . . alleviates galvanic corrosion which otherwise results from aluminum and copper junctions.

For the Sake of Argument

"So I'm Wrong!"

By Norman G. Shidle

Nobody likes to admit he is wrong. It hurts some people more than others. But nobody *enjoys* it.

Yet, how often most of us neglect the simple steps to avoid inflicting this particular kind of pain on ourselves . . . or on others.

One such step, of course, is to recognize that truth is no truer, nor facts more factual when stated sharply and unequivocally. A correct fact will justify itself without our arraying ourselves forcefully on its side. A truth will find acceptance when stated as a probability, just as well as when pronounced as an axiom.

Such recognition leads to statements which rarely saw off behind us such limbs as we may crawl out on. It leads to saying things tentatively, so that a listener may pick them up and make them his own. It leads away from too positive statements which hinder reception by the equal and opposite forces set up in the listeners' minds.

So, we spare ourselves the pain of having to admit we were wrong—or, at least, not quite right.

And, in reverse, we spare others that pain when we don't saw off the limbs on which *they* have gone out—even when the limb is low and the saw handy. We spare them when we look for ways to get listeners to admit a true fact without touching their previous statement that it was not true.

Aside from sparing pain, this approach often gets desired results quicker and more surely. Usually our real aim is to get a right thing recognized as right—not to prove that somebody was wrong. . . . And every one of us shifts position quicker if he doesn't have to admit being wrong before.

It's dangerous, too, to take much pride in being right. The more we do, the worse we feel when we turn out to have been wrong.

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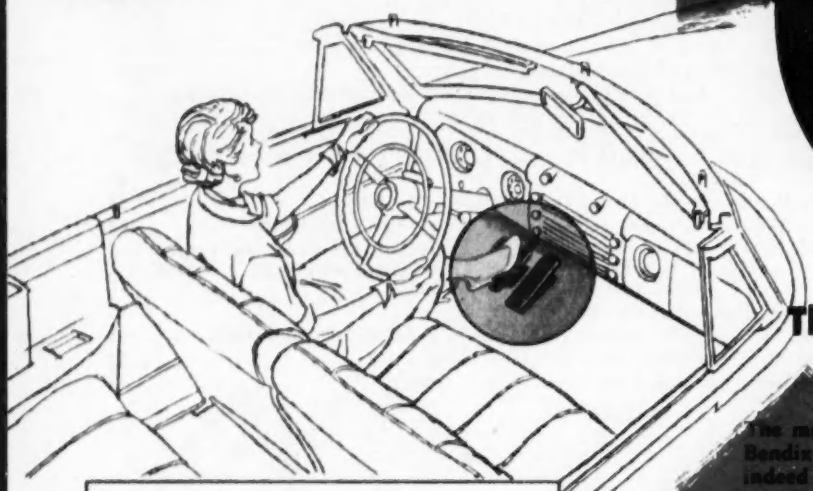

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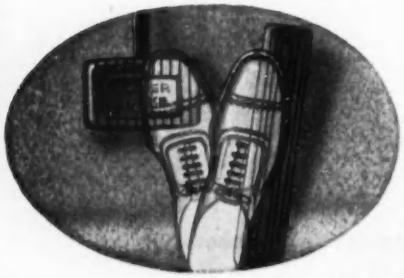

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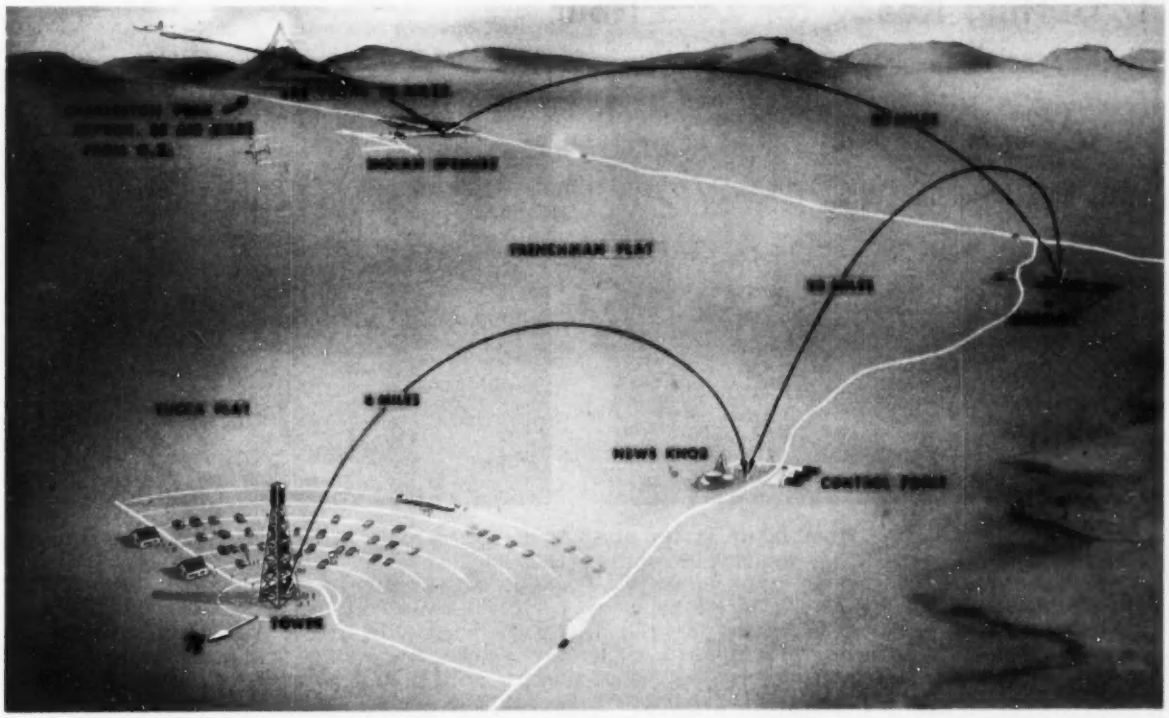


What Are the Odds When A-Blast Hits Autos?

A. L. Haynes, Ford Motor Co.

Excerpts from report of the SAE-FCDA Advisory Committee "The Post-War Car and the A-Blast . . . What Are the Odds?" presented by Committee Chairman Haynes at SAE Summer Meeting, Atlantic City, June 9, 1953.

WHAT would happen to the family automobile in the event of an atom bomb attack?

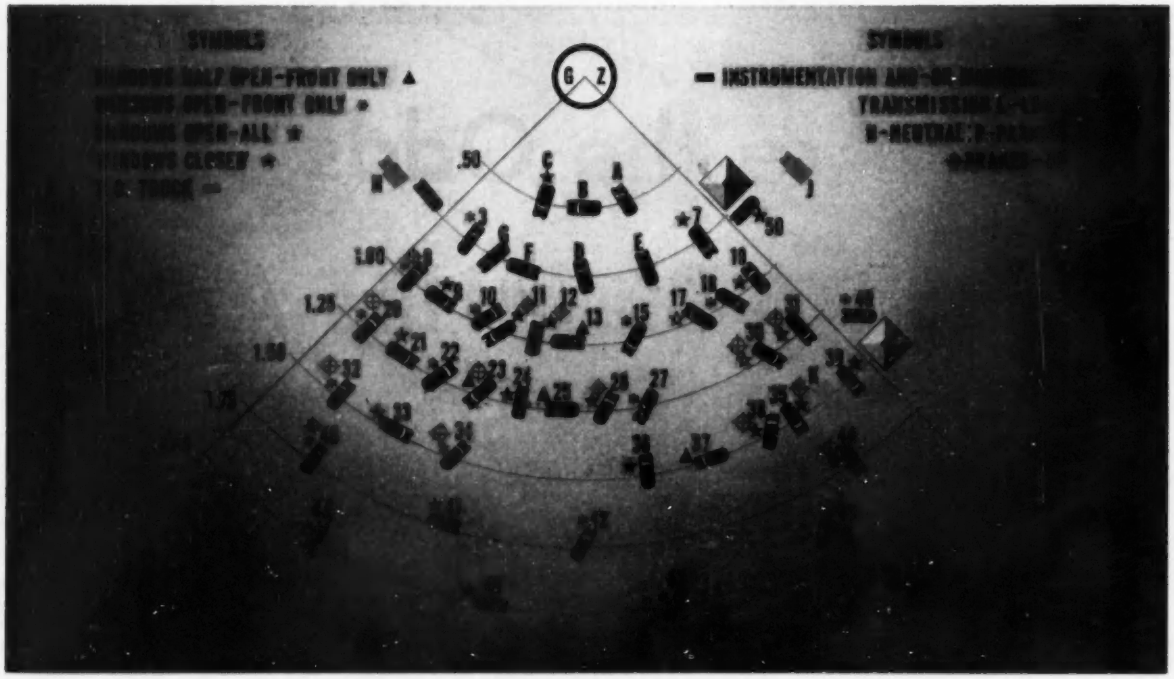
Not too much if it is beyond the major damage radius of an atomic burst. And you would probably be able to operate it too. Nor are there any significant differences between makes and models of cars.

Those are the preliminary findings from the atomic test at Yucca Flats, Nevada, on March 17 of this year, participated in by the SAE-FCDA Advisory Committee, in cooperation with the Federal Civil Defense Administration. (The test site is shown above. Preliminary work and test results are discussed on the following pages.)

1. Getting Ready for Zero Hour

The test vehicles came from many states and from two main sources. The major automotive manufacturers gave a group of cars and the National Automobile Dealers Association donated a number of cars. Three Post Office trucks were tested for the Post Office Department. The Atomic Energy Commission provided a few "clunkers" that were placed as far up front as was deemed advisable. There were some 51 vehicles that went through the test.

The cars were gathered in the big "Helldorado" enclosure in Las Vegas. This is a fenced-in area for the purpose of holding rodeos and "Last Frontier" shows. The cars were numbered and inspected and a pretest data sheet was filled out for each automobile.



In placing cars for the test, many conditions of driving and parking were simulated. All cars were arranged as nearly as possible along arcs with Ground Zero as the center. Cars were a quarter-mile apart along the arcs. First arc was one-half mile from Ground Zero and the last arc at the two-mile radius.

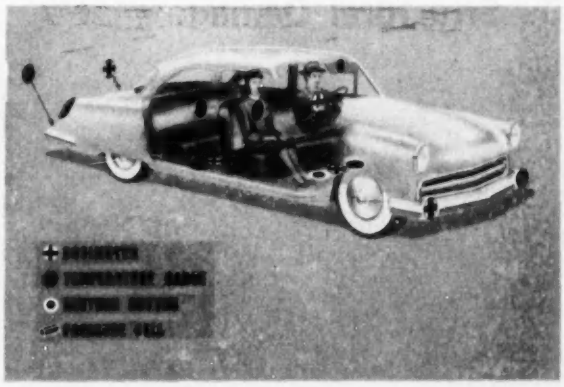
Cars faced toward, away from, broadside to, and at angles toward and away from Ground Zero.

Some had windows open, some partly open. Some had full tanks of gas, some half full, some almost empty. Some were in gear and some had the brakes set. These conditions and positioning were all prearranged by the Committee.

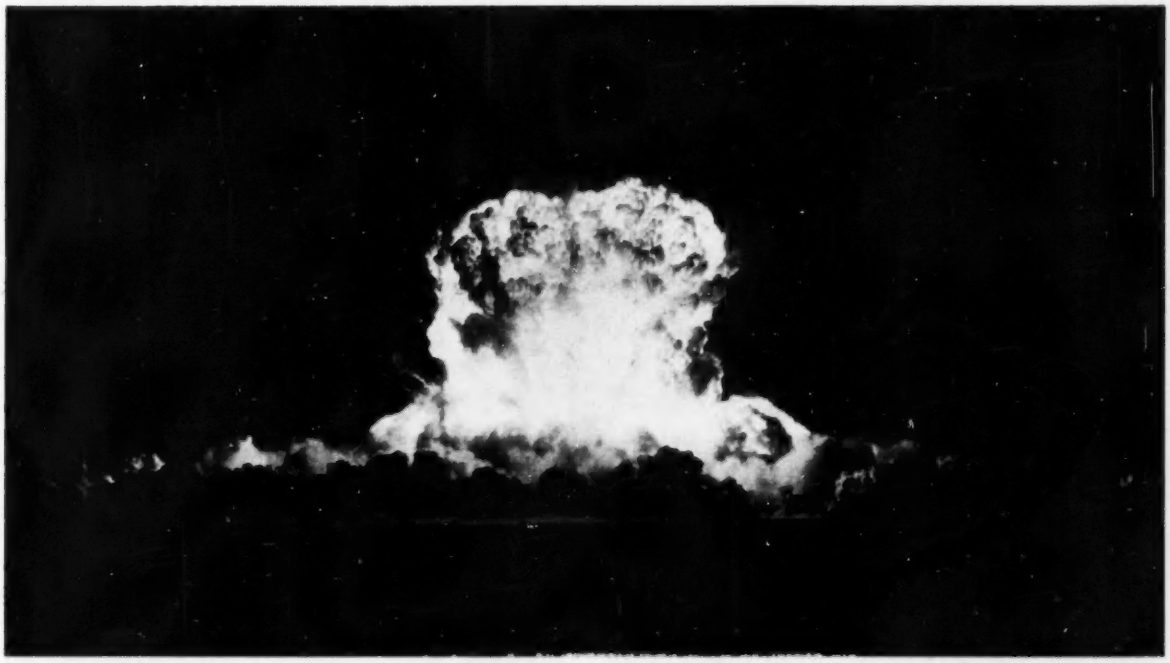
One car was placed close to each of the two test houses—one at 3500 ft, the other at 7500 ft from the tower. The cars were behind the first house and at an angle in front of the second house. One Post Office truck was beside the house at 3500 ft from Ground Zero.

In 24 cars FCDA project personnel had placed fully clothed mannequins.

AEC placed temperature gages and dosimeter and neutron badges, to measure radiation, in different locations on cars, such as seat backs and cushions, floors, steering wheels, bumpers and sun-visors. A few pressure gages of an experimental type also were used. These were to be collected as soon as it was possible to get into the area after the test and to be forwarded to Washington for processing. This work was finished by late Saturday afternoon.



2. . . . And then Came the Blast



At 5:05 a.m. on March 17 came the deep, omnious voice of the announcer with a 15-min warning. He told everyone there at News Nob not to look directly into the blast for the first instant. There was danger of seriously injuring the eyes at our distance of six miles from Ground Zero, unless special goggles issued to us were worn.

At 5:10 a.m. the ten minute warning—

Again at 5:19 the one minute warning—

You could have heard a pin drop on that ledge. And then the count—ten seconds—nine—eight—seven—six—five—four—three—two—one

Looking 90 deg away from the direction of the tower at the zero second, and even through those thick black goggles that made a bright headlight look like a tiny firefly, the landscape for miles around suddenly became as bright and as brilliant as on the sunniest day in June, perhaps even brighter. It was beautiful, horrible, terrifying, all in one. Dante would have had a difficult time describing that inferno.

At 1/10 millisecond after time zero the luminosity as observed at a distance of 5.7 miles was 100 times that of the sun as seen from the earth's surface.

The temperatures at the center of the explosion reach the levels of those at the interior of the sun —over 1,000,000 F and of course the tower was completely vaporized. The ionization right after the blast was a display never to be seen on the Fourth of July. And then the huge pillar of radioactive dust mushroomed up across the flats.

3. Structural Damage

There was no significant structural damage to frames, front and rear suspensions, motor mounts, or other structural parts. There was no apparent structural damage even when cars were rolled over.

In general, cars which were oriented broadside to the blast overturned at ranges comparable to less than three-quarters of a mile from the 15 kiloton tower-shot of March 17.

Cars that could be operated before the burst would operate after the burst, provided they did not burn.

Cars parked near buildings may be endangered by debris from collapsing buildings. The cars placed near the test houses were damaged in this way.

(The March 17 shot has been referred to as a "baby bomb," or a "low power" device. Such phrases are entirely misleading. For example, a frame house located 3500 feet from ground zero that was almost completely demolished by the 15 kiloton shot, would have sustained the same damage a very short distance farther away from a 20 kiloton "nominal" bomb.)

4. Glass Breakage

Glass breakage was common at the closer ranges. In terms of the March 17 shot, most glass breakage occurred within a mile and a quarter from the tower.

Safety plate glass at near ranges was blown out in large pieces which were badly cracked and crazed, but which did not shatter. However, not all windows in any car broke, in most cases. There were many instances where safety glass gave under the blast impact, but did not entirely blow out of its frame. In a few cases, only a relatively small hole was opened in the center of the caved-in glass.

Tempered glass of the type commonly used in rear windows of passenger cars did not splinter; they broke into countless small particles, some of which were blown a considerable distance at apparently high speed. Curved windshields and rear windows generally resisted failure from blast better than small or similar size flat glass surfaces.

5. Fire Damage

Based on the March 17 test, the percentage of cars lost to fire was surprisingly low. Where fire occurs it apparently begins with smoldering of seat covers, head liners, or door panels.

Burning of upholstery from heat flash was little different from that sometimes caused by dropping lighted cigarettes on upholstery.

There was some scorching of paint, tire sidewalls, and other exposed surfaces, as shown above. And, as expected, the darker colors generally were more susceptible to heat effect than the lighter ones. There was evidence that some paint softened from heat flash, allowing sand and gravel from the blast wave to impregnate it.

There was no evidence whatever that the gasoline tanks or fuel systems contributed to the initial fire hazard. No gas tanks exploded, even where the car was ultimately burned out entirely. This was true regardless of the amount of gas in the tank; amounts varied from one-eighth tank to full. Nor did it seem to matter whether the gas tank was capped or open.

6. Other Physical Damage

There was no significant difference between makes or models of cars, with the exception of wooden-bodied station wagons. As might be expected, these were less blast-resistant. (See photo above, at left.) There were no convertible models tested.

The only tire failures were due to fire, with the exception of one blow-out caused when a Post Office truck overturned.

In cases where car windows were closed, the most general damage was dished roofs and side panels. In the March 17 shot, cars with closed windows at the one and three-quarter and two mile zones suffered dished tops, as in the photo above at right and on the next page. Cars at these distances with windows open suffered no important damage.

The big, square-bodied post office trucks did not

react differently from the passenger cars, with the single exception of a truck oriented broadside to the blast. This was blown over at the three-quarter mile range during the March 17 shot, while all passenger cars, except a station wagon in the same cluster, remained upright.

Hoods and trunk lids were sometimes blown or sprung open. Some doors were jammed making a quick exit difficult.

7. Radiation Damage

There were no apparent physical effects on cars from the initial radiation of the bursts. Some cars were exposed to "fall-out" (dust being rained-out or settled-out from the cloud which is formed after the shot) and consequently were contaminated. Closed windows and doors would help keep it out.

All cars, when removed from the firing area, were subjected to radiological safety procedures. These included careful monitoring of the entire car to determine the levels of radioactivity, then decontamination, if necessary. In some cases decontamination was carried out simply by washing the car. In others, upholstery and interiors were vacuumed.

Some cars required minor decontamination because project personnel had carried radioactive material into the cars on their feet. All cars were successfully decontaminated and declared to be "rad-safe"—that is, a radiological safety officer declared that they did not constitute a radiological safety hazard of any kind.

8. Where Do We Go from Here

The observations given here are strictly opinions of the SAE Committee. The Committee is still working with FCDA on official interpretations. It should be emphasized here that all the observations and opinions are made on the basis of one test—the March 17 burst. It was a tower shot and it was held out in the open desert.

In the Spring series of tests, there were over two hundred car exposures. These will be subjected to a detailed statistical analysis by the SAE, and biomedical experts of FCDA and AEC before final conclusions or recommendations are made to the motoring public.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

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HOW METALS WEAR

W. E. Jominy, Chrysler Corp.

Excerpts from paper "Mechanism of Wear" presented at the SAE Annual Meeting, Detroit, Jan. 13, 1953.

THE mechanism of metallic wear is a tremendous subject that has been scrutinized for many years. It is such a complicated phenomenon that nearly any statement regarding it may be true or false, depending on other complications. Attempts have been made to generalize on wear behavior to give designers and their advisors some guidance in developing their new designs. Unfortunately, these generalizations have not been very widely accepted.

We do know, however, that certain factors influence wear. Moreover, perhaps we will all agree that lubrication is at least one of the most important, if not *the* most important consideration.

Too much emphasis cannot be placed on assuring the presence of a lubricant between the wearing surfaces. In my experience, omission of a lubricant of the oily type can multiply wear by a million times.

The lubrication can be of either the boundary or the full-fluid type.

Fig. 1 shows an example of boundary lubrication. This condition can vary in degree from several areas touching to many areas in contact, which allows some wear to occur.

The ideal condition—full-fluid lubrication in which no metal is touching—is depicted in Fig. 2. Actually, this condition rarely occurs, since a few areas of metal are usually in contact.

We have boundary lubrication when the movement between wear surfaces is zero. During this period, it is advantageous to have some constituent in the lubricant that is not squeezed out. Additives can be used in the oil that contain polar molecules that cling tenaciously to the surface. They have a high energy of adhesion and prevent the mating surfaces from welding. Some kind of coating on one or both of the mating surfaces also helps to prevent galling by preventing welding. If such a coating is a polar molecule, it functions also to hold the oil, and particularly the additive, with great tenacity.

Next to lubrication comes load as a factor in wear. Actually, wear has a very gradual effect until a certain critical load is reached. Beyond this point very fast wear occurs.

With very high loads, the lubricant will be squeezed out, with the result that much heat may be generated.

Loads of 4000-5000 psi have been found to be critical with cast iron. That is, below this point, wear takes place at a low rate and above it the wear is rather rapid.

These loads were observed on a wear test machine with a continuous motion and good lubrication. The lubricant, however, had a low viscosity, for it consisted of a light lubricant mixed with kerosene.

With reciprocating motion, which resulted, of course, in boundary lubrication, loads of only 900 psi were critical. In this case the lubricant was an SAE 5W oil with no kerosene added.

When we used hardened SAE 52100 steel running against the same steel with reciprocating motion under the same conditions as with the cast iron, the critical pressure dropped to 200 psi.

Next in importance as far as wear is concerned come abrasives and corrosion media, either of which can be very nasty or only mild, depending on their nature. After these come a host of contributing causes, such as speed of travel between the wear surfaces, composition, hardness and microstructure of the wear surfaces, surface finish, period for wear-in of the mating surfaces, the geometry of the wear surfaces, the kind of motion, and the surrounding temperature.

Types of Wear

Wear can be produced by cutting, by abrasion, by welding, by corrosion, and by fatigue. If oil separates the wearing surfaces, cutting and welding are eliminated, and if the oil is free of abrasives, then abrasion is also eliminated. Some erosion can occur with the surfaces separated, but this is very slow under most conditions.

Oil covering the surfaces at all times helps to reduce corrosion, but it cannot much affect fatigue, which causes pitting.

Cutting is, perhaps, the simplest kind of wear, It can be explained by considering it as being similar to pushing a file across soft metal. Examination under a microscope of the particles removed by

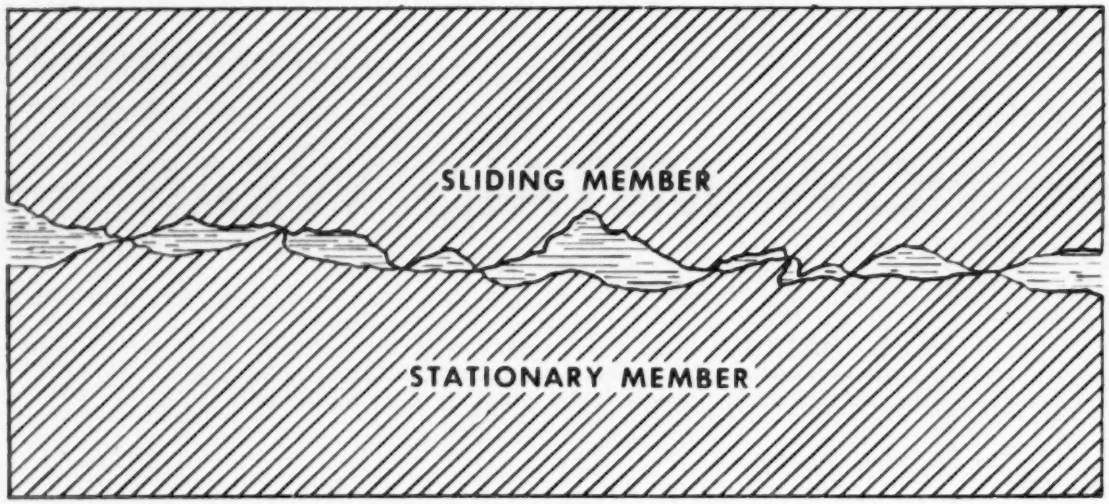


Fig. 1—Boundary type of lubrication

the file will reveal small chips, some of which will be broken into small particles. Similarly, during wear when a hard, rough surface is pushed past a softer surface, small chips will be cut and plowed out. Some of these will be caught between the surfaces and cut or crushed into particles.

In the case of abrasive wear, a similar action takes place. Hard, abrasive particles plow through the metal or bury themselves in it and push the surrounding metal up so that it is higher than the plane of the rest of the metal. This then acts as a cutting tool until it is cut off by abrasives. When a soft metal is one of the mating surfaces, the abrasives often lodge in the soft metal and act as a lap against the mating surface. The abrasive action is increased by the harder abrasives and coarser particles. In general, the finer the particles, the slower the wear.

One good example of an abrasive is dust, which is why it is so important to keep it out of the engine. We are constantly being reminded over the radio, television, and by other advertisements to use proper crankcase oil and to change it frequently. Practically nothing is said about the important air cleaner.

For every gallon of gasoline we burn in our automobile engine, we use ten thousand gallons of air. That is why a little oil in the air cleaner is worth many times its weight in gold to the car owner. I do not mean to be censuring the lubricants producers, but I do wish there was more profit in servicing air cleaners.

When two metal surfaces are clean and free from oxid, they weld at relatively low temperatures. When the two mating surfaces become warm enough and pressure is sufficiently high so that the

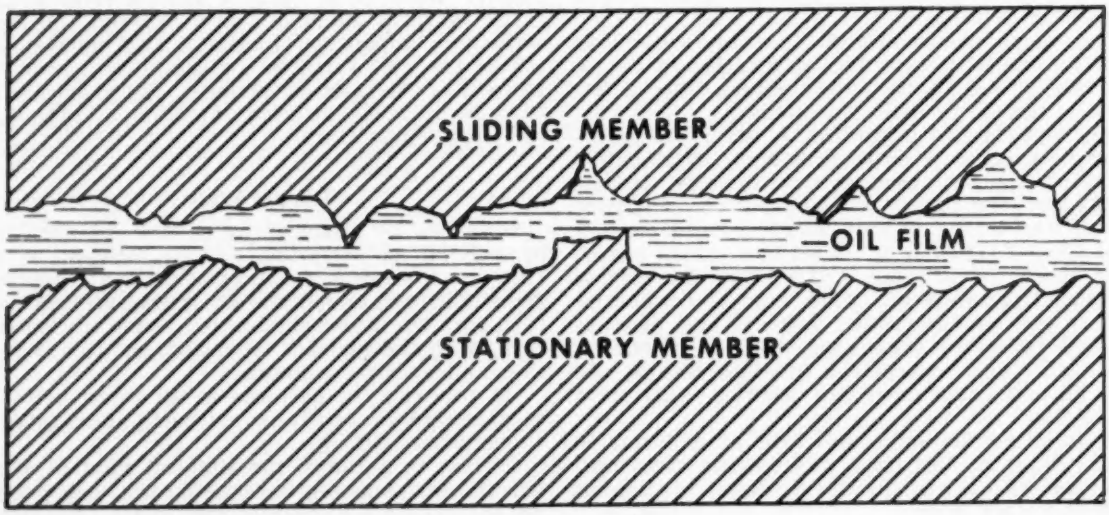


Fig. 2—Full-fluid type of lubrication

lubricant is squeezed out from between them and further action abrades small areas of the surfaces, they become temporarily chemically clean and weld in these areas.

These welds are immediately broken and, if the areas are small enough, only a slight roughening occurs, followed by cutting. This results in ordinary wear. If the welded areas are large, then galling or scoring takes place. It has been shown that the surface of two metals rubbing against one another can get very hot. They can even reach the melting point of one of the metals.

When galling occurs, rough surfaces are produced that cause very fast wear. The result is complete failure. To prevent this kind of wear, it is common to use a nonmetallic coating—such as oxids, sulfids, and phosphids—on one or both of the wearing surfaces. This coating should adhere tightly to the under metal. In addition, it is desirable to use an extreme-pressure lubricant.

So much has been said about corrosion in internal-combustion engines that it seems unnecessary to devote much space to this subject. It is true, as the radio commentators report, that the demon corrosion is a bad actor. It is probably worse in diesel engines, where the sulfur content of the fuel is usually much higher than in gasoline. Sulfur in the fuel definitely increases wear, even when no condensed water is present. Piston-ring wear is reported to be doubled when the sulfur content of the fuel is increased from zero to 0.5%.

When gasoline of the commercial grade is used, cylinder wear is increased sharply if the water jacket temperature drops to a point where condensation takes place. This varies with the pressure, but is usually about 140 F. There is, of course, a short period during the warmup of an engine when this condition exists. If the driver is careful not to load or race the engine during this time, he will enhance the life of his engine. After a temperature in excess of about 140 F is reached, the demon corrosion becomes quite amiable and ceases to torment the engine.

It has been pointed out that chromium-plated piston rings are superior because chromium is corrosion resistant. Chromium is, however, also very hard and resists wear exceptionally well when no corroding agent is present.

As to the mechanism of corrosive wear, it appears that the products of corrosion usually protect metal or at least slow down attack because of the presence of an interface. If, however, this interface is loose enough to be wiped off during the wearing process, corrosion can proceed more quickly. Further, the products of corrosion are somewhat abrasive, so that wear is also hastened.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Engine Development . . .

. . . can be accelerated by application of flexible test methods, which permit development work, usually done consecutively, to be carried on simultaneously.

BASED ON PAPER BY **E. W. Spannhake,** Barnes & Reinecke, Inc.

FACED with the problem of quick development of an almost completely new type of diesel engine for the U.S. Air Force, engineers at B & R tried to cut the necessary development time by intelligent planning and anticipation of difficulties. Significant in this planning were the coordination and simultaneous running of the work on test stands, as illustrated in Fig. 1.

Basically, the program for this lightweight, air-cooled diesel began in November, 1948. Building of the scavenging test stand took approximately one month. The injection stands were available. The C.U.E. test base, which formed the basis of the engine test stand, was also available through the good offices of the Armour Research Foundation, which helped substantially in the program, also providing test space and personnel. Design on the engine test stand began while actual tests were being started on the scavenging test stand. Fig. 1 indicates this and also shows that the discovery of the basic scavenging system occurred shortly before the engine test stand was scheduled to go into operation. Therefore, the largest amount of development work on the test engine could be done with the preliminary scavenging system, which gave the same scavenging pattern, but at a higher scavenging differential than the final one. For this reason, scavenging tests and engine tests overlapped considerably.

Use of the penetration test stand ended approxi-

SCAVENGING STAND	INJECTION STAND	PENETRATION STAND	ENGINE STAND	
BEGIN. OF TESTS	BEGIN. OF TESTS		BEGIN. OF DESIGN	1948
				1949
DISCOVERY OF BASIC PRINCIPLE	END OF PRELIMINARY TESTS			
CROSSED PORTS	CHECK TESTS		BEGIN. OF TESTS	1st Half
LOUVER PORTS		BEGIN. OF DESIGN		1949
BEGIN. OF INLINE PORTS		BEGIN. OF TESTS	FIRST GASOLINE TESTS	2nd Half
	BEGIN. OF REFINEMENT	END OF TESTS		
END OF DEVELOPMENT	END OF DEVELOPMENT		BEGIN. OF FINAL GASOLINE TESTS	1950
END OF TESTS	END OF TESTS		INSTALLATION OF FINAL SCAVENGING SYSTEM	1st Half
			END OF TESTS	

Fig. 1—Coordination and simultaneous running of work on different test stands speed development of new type of diesel engine

mately two months before completion of tests on the preliminary scavenging system on the engine. The preliminary injection system development was finished in time for the first engine tests. Further injection test stand tests tied in closely with the gasoline injection tests on the engine test stand, run in October, 1949.

About 1½ months after the final scavenging system was developed on the scavenging test stand it was introduced on the engine. Work on the engine stopped about two months after work on the remainder of the test stands. The satisfactory overlap of development time thus indicates that, by judicious application of flexible test methods, development, usually done consecutively, can be done simultaneously. The results—development of a new, aircooled, multifuel, lightweight diesel engine in this comparatively short time—it is believed, amply justify test planning and the use of flexible test stands, built especially for the occasion. (Paper, "Procedures Used in the Development of the B & R Air Force Diesel Engine," was presented at SAE National Diesel Engine Meeting, St. Louis, Oct. 31, 1952. Complete paper will be published in the 1953 SAE Transactions. It is also available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

Synthetic Lubricants . . .

. . . give promise of replacing petroleum oils to meet stringent demands of aircraft turbine engines. Study gives high rating to silicone-diester blend.

Based on paper by **Robert L. Johnson, Max A. Swikert, and Edmond E. Bisson**
NACA Lewis Flight Propulsion Laboratory

LUBRICATION problems in present and future turbojet and turboprop engines indicate the need to find new types of lubricants to replace current petroleum oils. Existing lubricants fall short because they are either too viscous for adequate pumpability at low temperatures or have marginal lubricating ability and excessive volatility at present bearing operating temperatures. New engines will have operational requirements of higher bearing operating temperatures and lower starting temperatures and there is no evidence that petroleum oils can fill the bill.

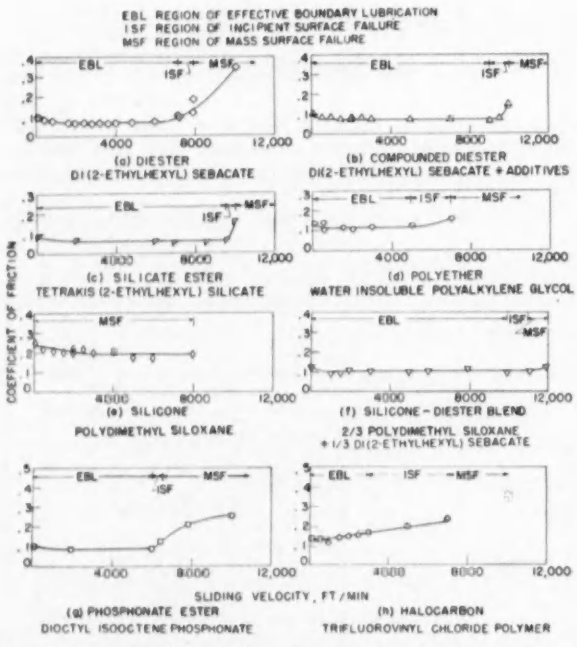


Fig. 1—Effect of sliding velocity on friction of steel surfaces boundary lubricated with several synthetic fluids. Load 269 g (initial Hertz surface stress 126,000 psi)

On the basis of their viscosity-temperature and thermal-stability properties, a number of synthetic fluids have been considered or merit consideration. Unfortunately, boundary lubrication and friction data are limited; hence a study was made to determine the boundary lubricating effectiveness of various classes of synthetics for steel surfaces with high sliding velocities. Results are given in Fig. 1.

It was found that a number of synthetics, including diesters, polyethers, a silicate ester, and a phosphonate ester, were more effective boundary lubricants at high sliding velocities than petroleum oils of comparable viscosity at 100 F; that is, the breakdown of effective lubrication takes place at a much higher sliding velocity with the synthetics.

A silicone-diester blend and a diester compounded with additives were more effective than were comparable diesters (without additives) from which the most widely accepted synthetic lubricants are made. The diester, di(2-ethylhexyl) sebacate, showed (Fig. 1a) incipient surface failure at a sliding velocity slightly greater than 7000 fpm and mass surface failure at slightly less than 8000 fpm. When the same diester fluid was compounded with additives for oxidation inhibition (phenothiazine), a viscosity index improver (methacrylate polymer), and an anti-wear agent (tricresyl phosphate), the incipient surface failure occurred at 9000 fpm (Fig. 1b).

Best performer of the lot was a blend of one-third di(2-ethylhexyl) sebacate in a silicone fluid (Fig. 1f). It proved to be an effective lubricant up to a sliding velocity of 11,000 fpm, while mass surface failure occurred at 12,000 fpm, although the failure was not extreme. (Paper, "Aircraft Turbine Engine Synthetic Lubricants and Their Lubricating Properties," was presented at SAE Annual Meeting, Detroit, Jan. 14, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

SYNTHETIC OILS

simplify turbo-engine lubrication

A. B. Crampton, W. W. Gleason, W. E. Lifson, and E. F. H. Pennekamp,

Standard Oil Development Co.

Excerpts from paper, "Performance of Turbo-Engine Synthetic Oils," presented at the SAE National Fuels & Lubricants Meeting, Tulsa, Nov. 7, 1952.

AIRCRAFT gas turbine engines of recent design are placing very great demands on the oils used to lubricate them. These demands are so great that petroleum-base oils are not able to satisfy them because these oils do not possess the required combination of the properties listed in Table 1.

In view of these basic shortcomings of petroleum oils, we undertook the development of wholly synthetic oils designed more nearly to fulfill the lubricant quality requirements of aviation turbo engines of recent design. Certain ester materials had been shown previously to possess excellent viscosity-temperature and viscosity-volatility properties, and ester-based hydraulic fluids, instrument oils, and greases were already in use. The promising characteristics of the ester materials were explored further in the laboratory, and new products of this type were developed to approach more closely the desired combination of properties.

Three oils of this type covering a range of properties have been evaluated in turbojet and/or turboprop engines. Oil A, the original member of this series, is of relatively high viscosity (7.9 cs at 210 F). It was developed initially to satisfy the requirements of British turbojet and turboprop engines. Oil B is a low-viscosity product (3.6 cs at 210 F) designed to give better low-temperature performance than oil A. Both these products are based on chemicals derived mainly from nonpetroleum sources. Oil C is another low-viscosity product (3.1 cs at 210 F) of particular interest because it is based on chemicals derived from petroleum raw materials. The petroleum-source chemicals are potentially widely available and lower in cost than the chemicals of nonpetroleum origin. It is believed that the properties of oils A and B can be duplicated with similar ester materials derived from petroleum-source chemicals. In Table 2 the properties of these synthetic lubricants most indicative of engine performance are compared with the conventional mineral-based oils, MIL-O-6081A grade 1010 jet-engine oil and MIL-L-6082A grade 1100 piston-engine oil.

As shown in Table 2, oil A exhibits better load-carrying capacity than the grade 1100 reference oil, carrying 105% of the load of the reference oil before gear scuffing occurs in laboratory high-speed gear tests. Oils B and C show somewhat lower load-carrying capacity (60 and 45% of reference, respectively) due in part to their lower viscosity. However, they are considerably better in this respect than the grade 1010 low-viscosity mineral oil. The latter carries less than 15% of the load of the reference oil. The outstanding gear and bearing lubrication shown by these oils as compared with mineral oils of similar viscosity is due in part to the use of a unique high-viscosity ester-type component having good load-carrying capacity combined with low pour point, excellent viscosity-temperature properties, and good high-temperature oxidation/corrosion stability.

Oil consumption characteristics of all three synthetic oils, as measured by evaporation rate or flash point, are good, indicating a ten- to fifty-fold improvement over the conventional light mineral oil.

By incorporation of a suitable inhibitor, these ester products all show much better high-temperature oxidation-corrosion stability than the mineral oils they are intended to replace. This is shown by the results of the MIL-L-7808 oxidation-cor-

Table 1—Quality Requirements for Turbo-Engine Oils

Performance Requirements	Desired Oil Property
1. Lubricate heavily loaded high-speed gears and bearings	1. Load-carrying capacity > 45–100% of grade 1100 mineral oil in high-speed gear rig
2. Low oil consumption at high temperature	2. Low volatility or evaporation rate (flash point > 400 F); nonfoaming; nondestructive to synthetic seals
3. Non-deposit-forming; noncorrosive	3. Thermally and oxidation stable and noncorrosive at 350–450 F
4. Pumpable at low temperature	4. Viscosity at minimum starting temperature < 5000–20,000 cs

Table 2—Properties of Ester-Type Synthetic Oils

	Synthetic Oils			Mineral Oils	
	A	B	C	1010 Jet-Engine Oil	1100 Piston-Engine Oil
Viscosity at 210 F, cs	7.9	3.6	3.1	2.5	20.5
Gear Scuff Load, % of grade 1100 oil	105	60	45	< 15	100
Flash Point, F	450	430	400	295	485
Relative Evaporation Rate at 400 F, % of grade 1010	2	3	10	100	1
Oxidation-Corrosion Stability at 347 F	Stable, noncorrosive	Stable, noncorrosive	Stable, noncorrosive	Unstable, corrosive	Unstable, corrosive
Temperature Range for 5000 to 20,000-Cs Viscosity, F	− 25 to − 45	− 55 to − 70	− 60 to − 75	− 45 to − 60	+ 5 to + 30

rosion stability test at 347 F, as well as by other laboratory tests.

The low-temperature pumpability characteristics of the oils are indicated by the temperature range corresponding to oil viscosities of 5000 to 20,000 cs. The synthetic oils show much better low-temperature properties than the mineral oils of approximately the same viscosity at 210 F. The synthetic oils cover a range of − 25 to − 45 F for the heaviest oil down to − 60 to − 75 F for the lightest oil.

Engine Performance

These ester products have been extensively tested in almost all of the turbojet and turboprop engines of advanced design in this country and in England. The test stand and flight test experience total over 10,000 hr in at least 12 different turbojet engine models and four different turboprop models. The experience with these oils in engines of different designs is summarized in Table 3.

Oil A, the original member of the series, has been tested in at least six different turbojets and three turboprop engines, mostly in the United Kingdom, for a total operating time in excess of 7000 hr. Oils B and C have only been used in the United States. Four different turbojet models and one turboprop engine model have been operated on oil B for a total operating time of over 4000 hr. Oil C, the low-viscosity product made from petroleum-source chemicals, has been used for more than 500 hr in three different turbojet models. Oil B conforms to specification MIL-L-7808 for turbo-engine oils, while oil A meets the major requirements of the British specification D. Eng. R.D. 2487 for synthetic aircraft gas turbine engine lubricants.

Table 3—Full-Scale Turbo-Engine Experience with Ester-Type Synthetic Oils

	Lubricant A	Lubricant B	Lubricant C
Viscosity at 210 F, cs	7.9	3.6	3.1
Country	United States and United Kingdom	United States	United States
Turbojet Engines			
No. of Engine Types:			
Flight Tested	> 2	2	..
Stand Tested	> 6	4	3
Approximate Total Test Time, hr	> 6000	> 4000	500
Turboprop Engines			
No. of Engine Types:			
Flight Tested	> 1	..	..
Stand Tested	> 3	1	..
Approximate Total Test Time, hr	> 1000	200	..

The results of these tests in turbojet and turboprop engines—in terms of the basic performance properties listed in Table 1—are shown in Tables 4 and 5. For comparative purposes, the performance of the mineral oils used previously in turbojets and turboprops is also shown.

The bearing and accessory gear lubrication with all three synthetic oils was adequate in all turbojet engines, as shown in Table 4. Grade 1010 mineral oil, on the other hand, permitted some gear scuffing and bearing wear in the most critical engines.

All three synthetics gave low oil consumption, due to their low volatility, while oil consumption for grade 1010 was excessive in critical engines, due to high volatility and/or excessive foaming.

It should be noted here that better sealing materials are needed for use with the ester-type synthetic oils. Most of the synthetic rubber seals now in use were designed for petroleum oils or fuels, as these were the best materials then available. They deteriorate badly in synthetic oils at high temperatures, particularly in the oils of lower viscosity. Synthetic rubbers specifically designed for use with these ester-type oils at temperatures up to 300–350 F are being developed by the seal suppliers, and it is believed that these will show a marked improvement over present materials. At higher temperatures, seals of different design using materials more temperature resistant than synthetic rubbers will probably be necessary.

As regards deposits and corrosion, all three synthetic oils were similar, giving light to medium deposits on the oil filters and in the high-temperature regions, such as the turbine bearings and engine midsection supporting structures, but no cor-

rosion was encountered. In contrast to this, grade 1010 oil gave medium to heavy coking in the high-temperature regions of the most severe engines.

Data on the low-temperature pumpability limit of the oils are meager but, as might be expected, results varied from engine to engine, owing to differences in oil system design. In general, however, the low-temperature pumpability limit seemed to correlate with the temperatures corresponding to oil viscosities in the range of 5000 to 20,000 cs for both mineral oils and synthetics.

These tests in the turbojet engines of advanced design have demonstrated the suitability of the ester oils for this severe service, wherein the conventional petroleum oil is unsatisfactory. Oil A is satisfactory when engine starting below −40 F is not required. When starting at lower temperatures is necessary, oils B and C are more suitable.

As far as turboprop engines are concerned (Table 5), the main difference in the synthetic oil performance, as compared to the results of the turbojet-engine tests, is in propeller reduction-gear lubrication. Here an ester oil with load-carrying capacity approximately equivalent to oil B was not completely adequate for the most severe engine. Oil A, which showed better laboratory load-handling ability, gave good performance in this regard for all engines. The MIL-0-6086 grade M (AN-0-3 grade M) mild extreme-pressure type of gear oil and the grade 1100 straight mineral oil gave good gear lubrication, but have poor low-temperature properties, and both gave medium to heavy deposits in high-temperature service. In addition, the mild extreme-pressure oil was corrosive to certain metals at high temperatures. Oil A possesses sufficient viscosity at high temperature to provide satisfactory operation of the hydraulically operated constant-speed-propeller governing mechanism currently used on British turboprop engines. Due to its better viscosity-temperature properties, satisfactory propeller feathering time can be obtained at much lower temperature than is possible with mineral oils of adequate high-temperature viscosity. Oil B is suitable for U.S. turboprops because propeller control mechanisms of different design are used. Low-temperature pumpability data for turboprop engines are very limited.

The turboprop-engine tests have shown that the ester oils are markedly superior to the mineral oils previously used. Oil A is suitable for all engines at temperatures above about −40 F. Oil B should be satisfactory at lower temperatures for most U.S. engines but better load-carrying capacity is believed to be necessary for the most critical engine.

Future Developments

The outstanding performance of the ester synthetic oils, in comparison with previously used mineral oils, has been conclusively demonstrated by extensive engine testing. However, these tests have also uncovered areas for further improvement in lubricant performance. Better load-carrying capacity in a low-viscosity oil suitable for the most severe U.S. turboprops would be desirable. Oils with even better high-temperature stability, as evidenced by lower deposit-forming tendencies, would be advantageous. This feature is particularly important, as the engine designers would like to increase oil temperatures even further in order to improve engine and aircraft performance. Anti-rusting characteristics built into synthetic turbo-engine oils without sacrificing other performance characteristics would provide an added measure of protection for engines during periods of nonoperation. Although not a performance characteristic, the problem of wide availability in times of national emergency is of utmost importance. As previously mentioned, the ester-type oils based on chemicals derived from petroleum are potentially widely available and lower in cost than those derived from other sources. It is believed that these petroleum-source synthetic products will eventually be the most widely used type.

Table 4—Performance of Lubricants in Turbojet Engines of Advanced Design

	Mineral Oil	Ester-Type Synthetic Oil		
	Grade 1010	A	B	C
Viscosity at 210 F, cs	2.5	7.9	3.6	3.1
Gear and Bearing Lubrication	Some scuffing and wear	Excellent	Good	Acceptable
Oil Consumption	High to excessive	Low	Low	Low
Deposits and Corrosion	Medium to heavy deposits, no corrosion	Light to medium deposits, no corrosion	Light to medium deposits, no corrosion	Light to medium deposits, no corrosion
Low-Temperature Pumpability Limit	− 40 to − 65 F	− 40 F	− 50 to < −65 F	..

Table 5—Performance of Lubricants in Turboprop Engines of Advanced Design

	Mineral Oil		Ester-Type Synthetic Oil	
	Grade 1100	MIL-0-6086 Grade M, Mild Extreme Pressure	A	B
Viscosity at 210 F, cs	20.5	8.6	7.9	3.6
Gear and Bearing Lubrication	Good	Good	Good	Some gear scuffing to acceptable
Oil Consumption	Low	Low	Low	Low
Deposits and Corrosion	Medium to heavy deposits, no corrosion	Heavy deposits, some corrosion	Light to medium deposits, no corrosion	Light to medium deposits, no corrosion
Low-Temperature Pumpability Limit	+ 30	..	− 40	..

If you want to introduce Quality

. . . here are some tips on how of organization, vendor relations, salvage

Organization, Vendor Relations, Salvage

D. E. Taylor, Pratt & Whitney Aircraft

Based on Secretary's report of Panel on Inspection and Quality Control held as part of the SAE National Aeronautic Meeting, New York City, April 20, 1953. Leader was E. S. Marks, Pratt & Whitney Aircraft.

AT this panel session such phases of quality control as organization, responsibility, policing, vendor relations, and salvage were discussed.

Quality Control Organization—Some of the forms of quality control organization in use are:

1. The quality control department separate from inspection or production. In this form it acts as a liaison group between all departments and does sampling, policing, analyzing, and advising. This group works with inspection data and acts as a consultant to inspection.

2. The quality control department as the overall quality department to which all inspection functions answer. Many other functions relating to or affecting quality also answer here.

3. Another form of organization has quality functions in each of several departments. These would be production for process control where needed, inspection for sampling and sorting, and purchasing for vendor quality control.

4. Many combinations or deviations from the above were apparent from the statements and discussions on the various subjects.

To What Extent Are the Manufacturing and Quality Control Functions Responsible for the Quality of the End Product?—The well-used phrase, "quality cannot be inspected into a product, it must be built in" seemed to govern the answers to this question. The manufacturing department foreman was uncontrovertibly held responsible for producing acceptable quality and in most companies was free to release a new setup after checking the first piece. Some companies make inspection (quality control) responsible for approving a new setup before releasing it to production, whereas others prefer to use the quality control department as a policeman, hence forcing manufacturing to be sure that the first piece off a new setup is O.K. It was suggested that the quality control department has the function of controlling, policing, analyzing, and advising, so as to assist in guaranteeing quality in the end product.

Under the same heading of quality in the end product the question arose as to who should do the sorting of a lot if discrepant material was evident from a sample. It was brought out that the manufacturing department, being responsible for quality in the end product, should sort the lot. A discussion followed on who in the manufacturing department would be available—or have the equipment—to do the sorting. A solution to the problem of requiring two inspection groups (one for inspecting by quality control and one for sorting by manufacturing) seemed to be in having inspection do the sorting at the expense of the manufacturing department. This would have a definite financial effect on the manufacturing department and would force them to improve their quality.

Suggested Corrective Action for Recurring Discrepancies—Suggestions included:

1. Weekly quality review meetings for discussing causes and proposed remedies.

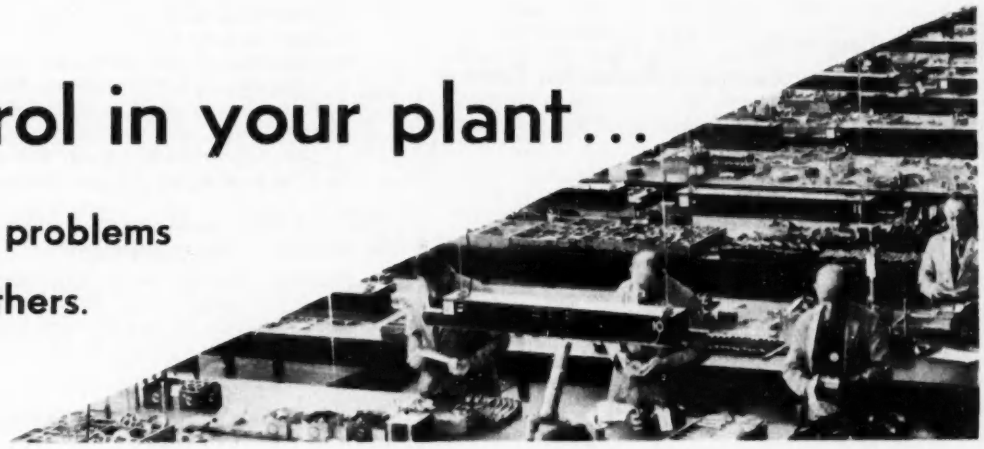
2. Inspection's job is service as well as sorting and helps by keeping records of rejections. These rec-

Continued on Page 33

Control in your plant...

to handle problems

. . . and others.



Selling Quality Control, Responsibilities

F. Galbos, White Motor Co.

Based on Secretary's report of Panel on Quality Control held as part of the SAE National Production Meeting and Forum, Cleveland, March 25, 1953. Leader was E. Gray, White Motor Co.

THE nature of the questions and discussions indicated great interest in establishing a clearer concept of the philosophy of quality control. In marked contrast to former panel discussions on this subject, no questions requiring an explanation of the statistical techniques were raised. But, there were repeated references to quality control in terms of its being an overall management function, separate and distinct from, yet including, both inspection and the statistical techniques of data analysis.

The panel felt that the results of statistical studies in the shop can be of great value to design engineers, who are too often unaware of their responsibility to the production process. Statistical quality control is submitted as a rational technique whereby specifications can be made consistent with the production process. Just as quality control is inducing the purchasing department to evaluate its suppliers, so it is leading engineering to take a new look at its tolerances.

Some of the more stimulating questions and discussions were essentially as follows:

Question: Is quality control just a fancy name for percentage inspection?

Answer: Quality control is a scientific method of gathering and analyzing data, differentiating the acceptable normal from the unacceptable abnormal, and indicating when control action is necessary. It is a whole series of activities aimed at defect prevention. At the same time, it frankly recognizes that some defects are inevitable and accepts them as normal. Percentage sampling is only one phase of quality control activity.

Question: How do you sell quality control to company management?

Answer: First, sell yourself on its value. Then, select for improvement a job with a recognized bad quality reputation. One survey showed that there is an annual loss of $500 to $1000 per worker per year, which can be converted to savings. Management men are practical men and best influenced by practical results with real problems.

Question: How do you sell statistical control to the bargaining units?

Answer: Introducing statistical control is not the same as buying a new machine. In the latter instance the union may not be concerned, but in the former it is. It is well to sell "job security" through reduced defects and to instill the thought that the "control chart is the worker's receipt for good work."

Question: Who is responsible for quality—inspection or production?

Answer: Although the panel was not in complete agreement, the consensus was that, in general, production is responsible for deciding whether a process should run and for allowing the process to continue in operation. Inspection is responsible for accepting the product. They

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are jointly responsible for defective material in the hands of the customer.

Question: How can you best organize to lick quality problems?

Answer: First, establish the problem clearly. Then, determine to solve it, and do everything necessary to accomplish this. Statistical methods are invaluable on problems of long standing because of their unique ability to separate the significant factors from the nonsignificant. Ordinarily, the manufacturing organization is prepared to handle the emergencies, but has not the time nor the training to solve long-term problems. This is best done by the quality control group.

Question: Should inspection be centralized or decentralized when there is more than one plant?

Answer: Generally, the plant manager should be responsible for inspection in his plant. This takes care of the day-to-day decisions. But the quality control group should be centralized, at least with respect to policy, in order to allow it to pursue a long range viewpoint on quality.

Question: Can a quality control program be set up where there is no specification?

Answer: No. All evaluation implies a standard. Where it is difficult to evolve a clearly defined standard, as in the case of visual qualities, other considerations are useful as guides, such as:
1. Will the customer accept the product?
2. Can the inspection decision be consistently reproduced?
3. Can the conditions surrounding the inspection be controlled or specified?

Question: How soon should a control chart be applied to new equipment?

Answer: Immediately. The chart can prove the machine's capability. One concern does not approve invoice payment until the control charts show the machine to be able to produce satisfactory work.

Question: In a job shop, how many pieces warrant a control chart?

Answer: It is recognized that charting small runs is impractical. Minimum lot recommended is 100 pieces.

Question: Where no critical defects are permissible, can you apply statistical techniques?

Answer: Yes, you can use the statistical method to help develop a production process that eliminates the making of bad pieces. One-hundred per cent inspection will not screen out all defectives if defectives are made. Since the machine itself inspects all the parts it produces, it should be given first attention.

Question: How do you eliminate the single critically defective piece where a metallurgical defect is involved?

Answer: One-hundred per cent inspection might reveal the single piece but not necessarily. The best care is prevention in the form of intimate statistical knowledge of the process.

Question: How do you control vendor's quality?

Answer: By vendor certification as to quality. This involves a listing of the points of importance, evaluation and classification of defects, and setting levels of acceptance. There must also be correlation of equipment and standards, audit checks, and evidences of conformance of some sort. There must be a prior agreement on policy with the vendor, followed by the exchange of basic data.
It is not unreasonable to expect that, in the future, manufacturing concerns will be classified on their quality performance in a manner comparable to commercial credit ratings.

Question: What is being done to standardize sampling plans?

Answer: Military standard 105A is finding broad acceptance. Some groups, such as the Screw Machine Products Association, have prepared standards applicable to their area of operation. Other producers will probably develop standards in a similar manner.

Other questions and discussion brought out these points:

Quality control is not necessarily statistical. Any philosophy that changes the thinking so as to produce good results is good quality control. Quality control is, consequently, a concept that goes beyond the bounds of inspection. In any attempt to gain control, it is well "to get everyone into the act." If, for example, an operator can be relied on to record the results of his own work, there is no reason why he should be excluded from doing so.

Likewise, if a production supervisor desires more frequent checks on a process admittedly out of control, it is well to give this to him. Quality control is an "overall view" that can override the limiting boundaries of departmentalized thinking.

Each panel member left a parting message as follows:

Use quality control to reduce costs, not just in production, but in all areas, office management, procurement, plant maintenance, and the like.

Remember that action is the essence of quality control. Without this, it is worthless.

Engineers must become more quality control conscious and more engineering thinking is needed in inspection.

Statistical quality control is an excellent aid to, but no substitute for, good inspection.

Quality control is common sense—but you have to exercise it.

Success in quality control is associated with active defect prevention. Failure is associated with a lack of such a defined practical objective.

(The report on which this article is based is available in full in multilithographed form, together with reports of the seven other panel sessions of the 1953 SAE National Production Meeting and Forum. This publication is available as SP-301 from the SAE Special Publications Department. Price: $1.50 to members, $3 to nonmembers.)

Organization, Vendor Relations, Salvage—continued from page 30

ords get data on cost as well as quantity in order that "first things can be handled first." With this means an economical balance between cost of defectives and cost of eliminating them can be obtained.

3. Disciplinary rejections. This was suggested as a means of forcing the manufacturing department into corrective action when inspection or quality review personnel know that the discrepancies are due to carelessness and can be fixed. It was suggested on this subject to let the manufacturing personnel know of the maximum quantity of discrepancies that will be allowed, thus forcing action.

4. Establish a corrective action group, whose sole job it is to eliminate recurring discrepancies.

5. Conduct process capability studies to show reasons for recurrent defects in order to establish whether action should be taken on equipment or people. These process capability studies may be used to advantage in requesting designers to review their tolerances where it is shown the present equipment and methods cannot meet them.

6. A question of whether an inspector has the authority to shut down a machine that is producing defectives was discussed. A definite difference in opinion existed, the contention of one school of thought being that the end product quality was the inspection department's only responsibility, whereas the other school contending that inspection should have the authority to shut down a poorly producing machine. In the latter case a red tag system is used so that the manufacturing department cannot run the machine until satisfactory corrective action has been taken. In this case the *threat* instead of actual authority for shutting the machine down is all that is required for the production department to take their own action and keep their quality high.

7. A question was raised as to how to answer the Military on corrective action when the economics does not warrant any action. Here it was suggested that MIL-Q-5923A permits and expects some discrepancies and hence the Air Force is and will be

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reasonable when presented facts concerning process average, costs, and the like.

Quality and the Vendor—The importance of good quality relationship with the vendor from the very start of the contract was stressed. This can be handled in several different ways, one suggestion being that a member of the quality control organization sit in with purchasing and a prospective vendor at the inception of the new order. In this way all quality requirements, standards, and the like could be fully explained and the vendor would have a direct tie with the department that is ultimately going to inspect his product. This aids in eliminating misunderstandings regarding specifications and hence saves strategic materials and speeds up deliveries. In one company this vendor quality group is a section of the purchasing department.

One restriction that several companies reported as very important was that vendors cannot be switched by the purchasing department without first authorization by the quality control department. New vendors may be started by studies and surveys of their quality characteristics, sampling plan results, certified reports, and the like.

It was brought out that a prime contractor should be prepared to supply a vendor with an aql (acceptable quality level) to which he may be held responsible.

A subcontractor raised the question as to why the aircraft industry could not set a single standard for a certain common product. The point in question was brought up in the case of a subcontractor who supplied several prime contractors making the same general product. After discussion the problem seemed to narrow itself down to visual standards or standards concerning opinion. On cases of this type it was suggested that samples, pictures, diagrams, or as much as possible in the form of quality standards be incorporated in quality manuals or standards. Many companies have established manuals covering standards for magnetic particle inspection, fluorescent penetrant inspection, resistance welding macro-examination, radiographic, and other inspections. It was further suggested that manufacturers of common types of parts might get together and work out standard dimensions, finishes, radii, and other nondimensional requirements. It was suggested that the SAE might help with such programs as they have done with so many other similar problems.

The most important consideration for the relationship between the subcontractor and prime contractor was to get as much of the quality requirements in writing on the B/P or referenced by the B/P to certain quality manuals or specifications.

Use of Statistical Quality Control in Process—It was suggested that the claims of statistical quality control about money savings could well be overshadowed by the better control and improvement in quality. A quality control department in one company has floor inspectors who are responsible for keeping a process in control. This reduces defectives found at final inspection and hence the final inspection may be reduced. Control charts are used on those operations where needed and in some cases the operators maintain them. In another company the quality control department supplies the forms, charts, and so on, and offers advice, but the responsibility for quality is still with the manufacturing department supervision. It was pointed out that the floor inspector system sometimes tends to allow the operator to get lax and lean on the service of checking and advising when trouble exists. To remedy this it was suggested to remove the control charts or process checking and sample a man's entire lot after being completed. If defectives are found, the operator should be reprimanded.

The station inspector method is advocated by some. In this method an inspector checks the work after it has passed through a series of several operations. This eliminates bad work from progressing further down the production line. Some companies pay a premium of 15¢ per hr to an operator who assumes the responsibility for the work of five other operators.

Statistical quality control was voiced as not the complete panacea to a manufacturer's prayer but an extremely useful tool that could and should be used much more widely and to much better advantages than it now is.

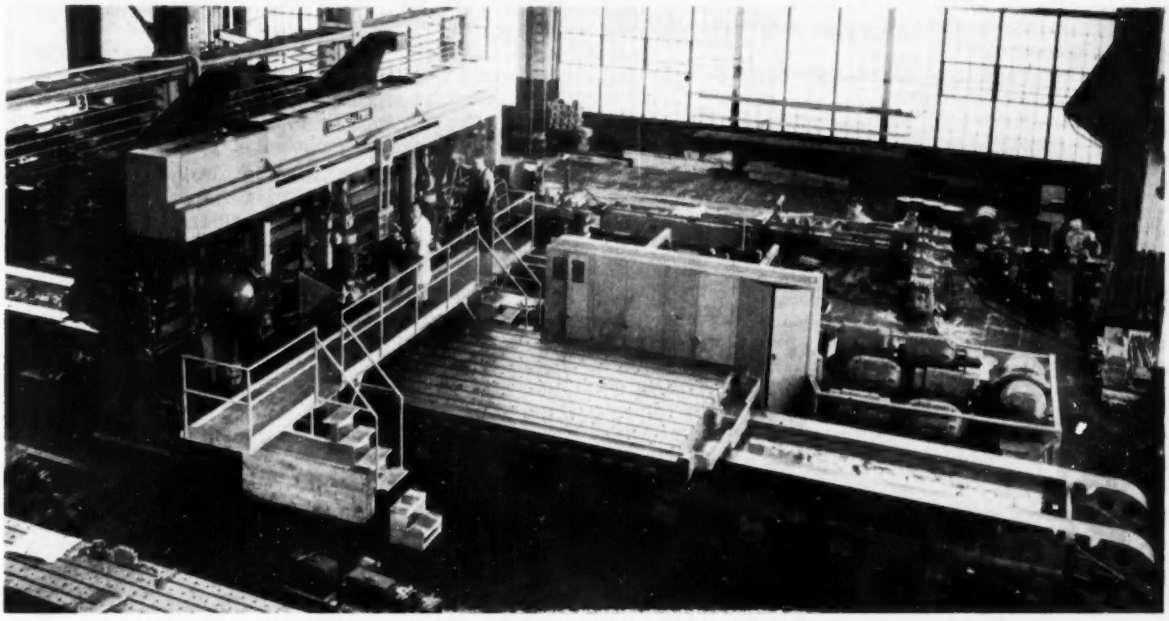
Air Force Surveillance Program—The new surveillance program of the Air Force was explained as allowing the contractor to act on his own. The Government inspector tells you, the contractor, when you are not doing well and asks that you report what you're doing about it. It is a check on the kind of a job your inspectors are doing. The purpose of the program is to force the quality control department to put pressure on the manufacturing department to do a better quality job.

What is Material Review?—"Salvage," "material review," "quality review" are just some of the names attached to the function of making decisions as to what disposition to make on off-spec material. The purpose of the function is to decide, through representatives of the Government (on military contracts), a contractor's engineering department, and the salvage department, whether the discrepancy will affect the function of the part or assembly. If it is decided that function and purpose will not be affected in any way, the part may be accepted. If safety is endangered in its use, the part will be scrapped. Every effort to avoid the need for salvage dispositions should be made as this function is very costly. The salvage material review, or quality review department is usually part of the quality control organization.

Tool and Gage Control—There was a wide divergence of opinion by both panel members and audience on this subject. One thought was that all jigs, fixtures, gages, and the like, should be examined for errors in application, and should also be inspected by quality control. This also applied to perishable tools such as drills, taps, and cutting tools. The other philosophy presented was that the quality control department should only concern itself with whether the end product satisfies the quality specifications.

(The report on which this article is based is available in full in multilithographed form, together with reports of the nine other panel sessions of the 1953 SAE National Aeronautic Meeting and Aeronautic Production Forum. This publication is available as SP-302 from the SAE Special Publications Department. Price: $2 to members, $4 to nonmembers.)

Monster aircraft skin milling machine—sizable evidence that . . .



Aero Industry Develops Appetite for Machine Tools

Adam Hetzer, Republic Aviation Corp.

Secretary's report of Panel on Machine Tools and Tooling held as part of the Aircraft Production Forum at the SAE National Aeronautic Meeting, New York, April 20, 1953. Panel Leader was A. Kastelowitz, Republic Aviation Corp.

FOR 50 years, the automotive industry has dined handsomely—and pretty much alone—on the huge crop of machine tools produced each year. Now a new gourmet—the aircraft industry—wants to share this repast.

Present aircraft designs are the tapeworms behind the aircraft industry's new-found appetite for machine tools. Sheet metal has become plate. Fabricated assemblies have become large forgings. And both call for use of machine tools!

Thus a market has been created for an entirely new species of machine tool. And it's one that needs to be met immediately.

How to do this without losing their shirts is the problem machine-tool makers face today. Whereas automotive machine tools were developed at a rate slow enough for private industry to finance them and were pretty sure to make money once built, such is not the case with aircraft machine tools. With aircraft designs changing so rapidly, the market for specific machine tools doesn't last long. Thus the development of the necessary tools becomes a highly speculative and risky business for tool builders.

In the past, the U. S. Air Force has footed most of the tooling bill for an airplane. Now it would appear that this "tooling" must also include special machine tools. In short, the only solution to this dilemma of tool makers appears to lie in the government putting up the money for special aircraft machine tool development.

As for the question of imported versus U. S. machine tools, these points were brought out:

1. Canadian tools should not be considered in

the same category as European ones since they are built according to U. S. standards.

2. Much of the dissatisfaction with foreign tools can be traced to:
   a. Underpowered machines—due to different motor standards.
   b. Less rigid tool frames—probably due to the foreign tool maker's belief that U. S. production loads are lighter than they actually are.

3. Foreign tools have been used in this country largely for one reason—availability. (In only one instance was the foreign market the only source for a certain machine tool.)

Whether for foreign or U. S. tools, however, the cry lately has been for faster speeds that would make possible higher production rates. To some experts at the session, this is a case of barking up the wrong tree. Instead of trying to shoot for reduced machining time, emphasis might better be placed on developing better handling and jigging equipment, they argued. For it's these operations that are the real bottleneck to stepped-up production.

But the right tools, handling, and jigging equipment aren't all that's needed for successful operation. Aircraft engineering and production departments ought to join hands in marriage. Their operating as separate entities just won't do.

Fortunately, current aircraft designs are promoting this marriage. That's because they embody components never before considered. Thus it becomes necessary for engineering to get assurance from production that they can be made before it can finalize on them.

(The report on which this article is based is available in full in multilithographed form together with reports of the nine other panel sessions held at the 1953 SAE Aircraft Production Forum, New York. This publication, SP-302, can be obtained from SAE Special Publications Department. Price: $2 to members; $4 to nonmembers.)

Propellant Injector Design . . .

. . for rockets is exceedingly critical, and tolerances are tight. Off-design flow impairs rocket efficiency so much that throttling is impractical.

Based on paper by **Raymond W. Young,** Reaction Motors, Inc.

THE injector at the head of the thrust chamber is the heart of the rocket.

Injectors must be designed and made very carefully to secure good results. A very slight modification in the slope of the injector slot or a change in the alignment of the injector holes can change thrust chamber efficiency 20–40%. Even tiny variations from optimum dimensions can result in local hot spots that burn through chamber walls in as little as 1 or 2 sec.

Fig. 1 shows schematically three of the many styles in current use to atomize and mix propellants.

In these and most other injector designs, throttling of the propellant flow from the design value would affect mixing, atomization, and momentum unfavorably. Rocket performance and combustion stability would suffer. So designers can't use throttling to achieve thrust reduction. Instead, they use multiple injectors or multiple thrust chambers and provide for shut-down of some units when thrust demand lessens.

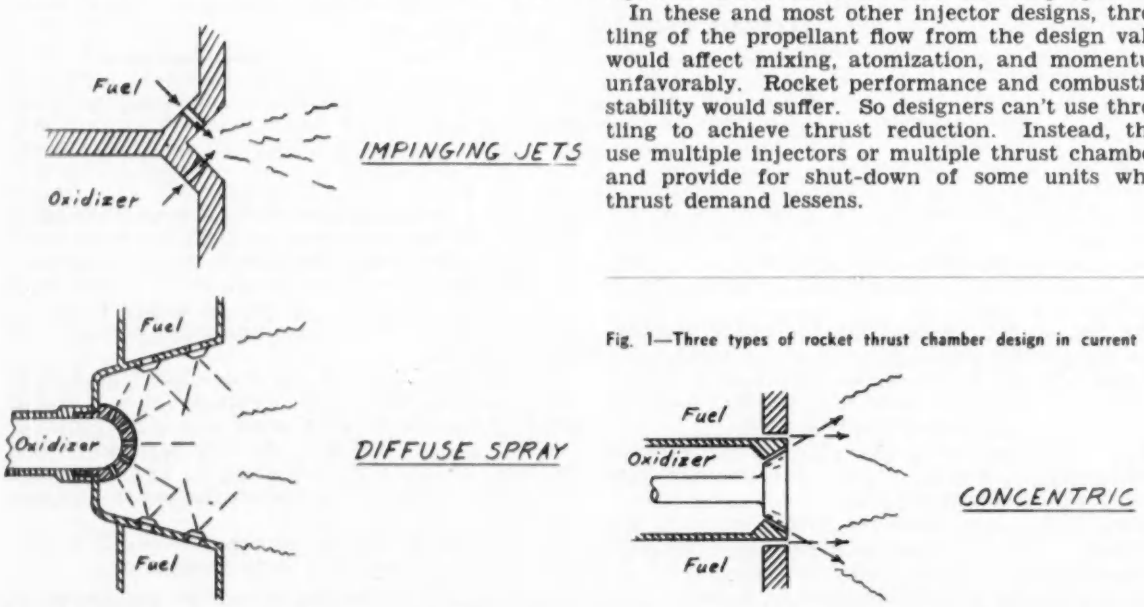


Fig. 1—Three types of rocket thrust chamber design in current use

How to Protect Magnesium Against Wear

E. L. Schaper, The Dow Chemical Co.

Based on paper "Wear Characteristics of Magnesium," presented at SAE Annual Meeting, Detroit, Jan. 13, 1953.

MAGNESIUM will hold up well in parts subjected to wear and abrasion ranging from foundry equipment to lawn mower gears. The material's wear resistance in any application can be bolstered by proper alloy selection, heat treatment, or surface coating.

Alloy selection makes a difference in performance of magnesium bearings. Several bearing manufacturers cooperating with Dow Chemical found this out in work on magnesium bearings. They discovered that magnesium bearings can be used directly as bearing material without using bushings or inserted bearings.

The survey showed that certain alloys had better bearing properties than common commercial magnesium alloys. Included in these special alloys were Mg + 6 Sn, Mg + Pb, and Mg + 20 Cd + 10 Pb.

The Germans also ran tests with similar cadmium-lead alloys, which showed slightly better bearing properties. German investigations repeatedly mention the non-seizing characteristic of magnesium bearings.

In these investigations and in other cases magnesium bearings were used successfully under higher loads and more severe conditions. The usual recommendations for magnesium bearings are as follows:

- Bearing loads should not exceed 2000 psi.
- Speeds should be no greater than 1000 fpm.
- Operating temperatures should not exceed 230 F.
- The steel shaft should be hardened or case hardened to at least 350 Brinnell, and preferably to a hardness around 600 Brinnell. The shaft should also be polished and ground.
- Ample lubrication should be provided.

The German automotive and aviation industries found that bare magnesium alloys had excellent bearing properties. The automotive industry was very successful using magnesium as a self-bearing material in camshaft bearings, pushrod bearings, and oil pumps. Roughly 95% of these pumps used the cast magnesium housing directly as the bearing material for the shaft.

In this country several automotive companies have laboratory- and road-tested magnesium oil pumps. Some cars have accumulated over 40,000 miles, one over 87,000 miles, and the magnesium is performing well.

Only Test Can Tell

Magnesium has met with unpredictable success in many other applications. For this reason the material merits a trial where it offers other advantages. Some typical examples are shown in the photographs on pages 38-39.

Up to now, few laboratory tests have been conducted on wear properties of magnesium alloys. Available comparative figures show that both increased alloy content, heat treating, and aging raise the hardness, but only slightly boost wear resistance. Under one specific condition tested, wear properties were improved by roughly 15% over the low-alloy and nonheat-treated magnesium.

There is no significant difference between cast or wrought magnesium. However, users of die-cast magnesium parts claim that a wear-resistant skin effect has been noticed. This could be the result

Table 1—Modified Tabor Test on Coated Magnesium and Aluminum Die Cast Specimens

Coating Type	Number of Cycles
1. Magnesium Dow 7 (Dichromate)	800
2. Magnesium Dow 9 (Galvanic Anodize)	1000
3. Magnesium Dow 12 (Caustic Anodize)	3000
4. Magnesium Manodized a-c Current	2600
5. Magnesium Manodized d-c Current	3500
6. Experimental Magnesium Anodize	22,000*
7. Aluminum Anodize (Sulfuric Acid heavy coating)	22,000*
8. Aluminum Anodize (Chromic Acid)	2000
9. Aluminum Anodize (Sulfuric Acid light coating)	3000

* Removed, no significant wear.

of a quickly chilled, fine grained surface layer.

Since alloying or heat treating has little effect on magnesium's wear resistance, surface coating is usually the way to get results. Three coating types used are plating, chemical treatments and anodic coatings, and metal sprays.

The chrome electroplating process is among the most significant of recent developments in magnesium finishing. The process consists essentially of a zinc immersion coating, followed by the application of a copper flash and electroplating in standard plating baths. The resultant copper-nickel-chromium coating gives wear characteristics like those of any other plated metal.

Plated magnesium printing plates are a good example of the potential gains. A chrome deposit on the plate's printing surface gives 10 to 20 times greater life.

Dixie Cup Co. found it got from 750,000 to 1,500,000 printed impressions from its copper-faced electrotype plates. Long press runs, common in the paper cup and container industry, often meant using three to 10 sets of electrotypes. A single chrome-plated magnesium plate now yields 15,000,000 to 20,000,000 impressions.

Trouble with plating is that it doesn't always hold up under highly concentrated or brinnelling type loads. Under such conditions, hardness of the base material also becomes a big factor in the surface coating's load-carrying ability.

The second type of coating is chemical treatments, such as the chrome pickle and dichromate of the surface conversion type for prepaint treatment. They do little to increase wear resistance. Their main value is to provide better adhesion for subsequent paint coatings.

Several anodic coatings available increase hardness and abrasion resistance of magnesium. These anodizes are still quite new. Future testing of both current coatings and those under development will show their real value in wear resistance. Limited use has been made of Dow treatments Nos. 12 and 14.

Treatment No. 12, or Caustic Anodize, is an anodic treatment using an alkaline bath in which a-c or d-c low-voltage current produces the coating. Its chief use to date has been in the textile field. The fact that it does not "crock" or rub off onto fabric makes it preferable to a paint coating. The aircraft industry also uses No. 12 type coatings in production.

Treatment No. 14, or a-c Anodic, is deposited on magnesium by electrolytic treatment in an alkaline bath using high-voltage alternating current.

No. 14 is somewhat more abrasion resistant than No. 12. It also has the ability to cover flow marks on die cast surfaces.

Another anodic treatment is the Simpson-Cutter process, also called the Manodize a-c or d-c and the CVAC No. 1 a-c or d-c. Tests show that coatings produced by this process give good protection and paint base qualities. We have specific information on the coating's wear resistance properties.

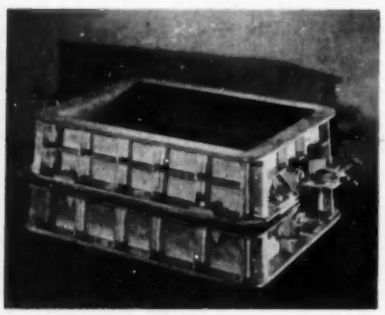
The optimum in anodizes for magnesium has yet to be developed.

Recently an automotive manufacturer asked us for a more wear-resistant coating for some particu-

Parts Where Magnesium

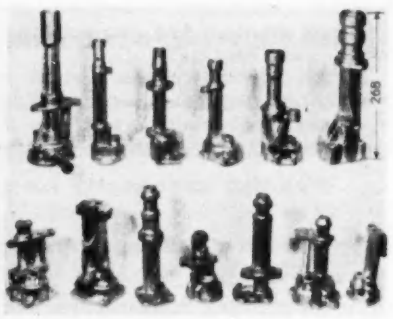
Core Boxes

In one foundry, magnesium core boxes resisted wear as well as those of aluminum, steel, and brass



Foundry Flasks

Magnesium sand foundry flasks combine the characteristics of light weight and wear resistance



Oil Pumps

All high production cars in Germany before World War II depended on die-cast magnesium oil pumps

lar applications. Several experimental coatings were tested.

One possible use involved magnesium rubbing against steel. So the first test was similar to the Tabor Abrasion test, except that a highly polished steel disc was used as the rubbing wheel instead of the usual calibrase wheel.

The dry surfaces on both steel and the specimen were tested. End point of the test was the number of cycles or revolutions to wear through the coating.

Table 1 compares various magnesium and aluminum surface coatings under these conditions. Both the experimental anodized magnesium and anodized aluminum coatings were removed at 22,000 cycles with no apparent wear. This was well over the number of cycles expected in actual service conditions of the proposed application.

Another similar test was made. It consisted of a cast-iron disc turning against the specimen. A 200-psi load was applied to the specimen. A 10 W oil was used throughout the test. All specimens were put through the same number of cycles and then examined.

Comparative values are shown in Table 2, given as a percent of surface coating worn off or through during the test. The test covered four magnesium anodizes and anodized aluminum.

The experimental anodized magnesium showed only 3% of the surface worn and the anodized aluminum only 5%. Manodized d-c current on magnesium was next with 45%, followed by Manodized a-c and Dow No. 12 at 75% and 80% respectively. The most significant result to us is the comparable wear resistance of the experimental anodized magnesium to the anodized aluminum.

A new electrochemical coating recently was developed at the Pitman-Dun Laboratory, Frankford Arsenal. This coating is called HAE, after the initials of its discoverer, H. A. Evangelides. In a recent article he said that the process produces a refractory coating which has excellent corrosion, heat, and abrasion resistance. We have heard reports of laboratory tests on the HAE coating which confirm the good wear resistance of the material.

From experience we have found that applying an oil, grease, or wax usually prolongs the life of anodic coatings. Impregnating the coatings with colloidal graphite further enhances it. The anodic coating acts as an insulating separator on the magnesium surface and prevents corrosion by the graphite.

Various metal spray coatings have been applied to magnesium with varying degrees of success. One spray recently reported is a chromium-tungsten metal combination. It is said to produce a hard wear-resistant surface.

Metal spraying on simple parts usually costs more than electroplating. But when the shape of the part presents plating problems or when only certain areas require the coating, metal spraying is not handicapped by the need of special anodes or stop-off lacquers.

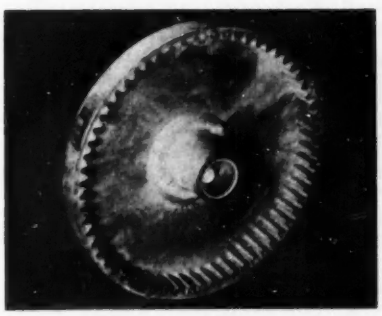
(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Table 2—Abrasion Test of Magnesium and Aluminum Against Rotating Cast Iron

	Percent Casting Worn*	Average Frictional Force at 200-psi Load
1. Magnesium Dow No. 12 Anodize	80	21.8
2. Magnesium Manodized A.C. Current	75	22.8
3. Magnesium Manodized D.C. Current	45	23.7
4. Experimental Anodized Magnesium	3	23
5. Anodized Aluminum (Sulfuric Acid, heavy coating)	5	19.5

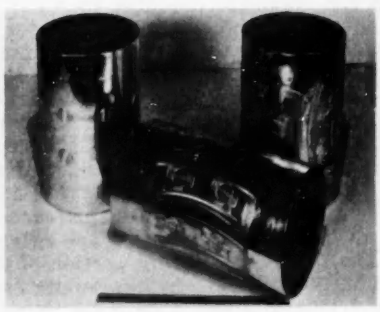
* Same number of revolutions for each specimen.

Has Resisted Wear



Lawn Mower Gear

One manufacturer has used over one million die cast magnesium gears with complete success



Printing Plates

The application of chrome plating made magnesium printing plates last 10 to 20 times as long as unplated ones

Sand Buckets

In one foundry, magnesium sand elevator buckets lasted longer than the malleable iron buckets they replaced

The Torque Converter Provides

THE increasing size and speed of today's off-highway trucks places severe requirements on the service brakes. Tire sizes have increased, along with the brake drums, until the brake drum size has about reached its physical limit. The trucks are becoming underbraked. Since the torque converter is not particularly concerned with the source of power driving it, a logical step was to couple the rear wheels to the converter during downhill operation. Full utilization of the converter was accomplished—a power transmission on adverse grades—a vehicle retarder on favorable grades.

The mechanical problem during the retarder operation was to couple the rear wheels to the impeller of the torque converter rather than to the turbine. The impeller is a more efficient pump than the turbine and can, therefore, provide the maximum fluid circulation within the converter. At the same time the stator blades must be either fixed or locked up by some clutch device.

The mechanical design of the Twin Disc 3-stage torque converter provided a ready solution. The model DF, providing a direct mechanical drive, needed only a fourth position of the control valve, causing simultaneous engagement of the converter and mechanical drive clutches.

First, consider only the direct drive or inner clutch engaged. The drive from the rear wheels is through the splined hub to the solid shaft, thence to the inner clutch hub. The engaged clutch drives the double clutch carrier, which in turn drives the input spider and the engine. Engine friction horsepower is then available for retarding.

Since the double clutch carrier is being driven by the rear wheels, engagement of the outer or converter clutch will also cause the impeller to be driven by the rear wheels. The turbine, until now, has not been in the picture, due to the freewheel mounted between it and the splined output hub. Oil circulation by the impeller causes the turbine to rotate at close to impeller speed.

The converter is operating at "racing" where, due to the fixed stator blades, the efficiency is zero but high horsepower is being absorbed just to circulate the oil against the resistance of the fixed stator blades. What was a problem in the transmission of power is now put to work as a retarder.

The retarding feature also proved to be desirable in the short-haul pit truck, where the direct mechanical drive is not employed. The Twin Disc model CF is equipped with a standard spring-loaded clutch. The retarding feature is obtained by the use of a freewheel located between the turbine and impeller in such a manner that when the rear wheels tend to drive the turbine, the freewheel engages the impeller. The two are then driven at identical speeds, along with the engine. The impeller establishes oil flow within the converter. Again, engine friction horsepower is added to the power absorption of the converter for retarding purposes.

Although the retarding ability of both units is similar, the model DF permits optional braking, while braking is automatic with the model CF anytime engine speed drops to turbine speed. The hazard of driver abuse is minimum with the model CF. Both units provide a "push to start" feature in the event this becomes necessary.

The horsepower available for retarding purposes varies with the capacity of the converter. This is obvious since the converter is first a power transmission device and therefore must be matched to the engine as described before. It also varies as the cube of the input speed and with speed ratio. A simplified horsepower absorption curve is shown in Fig. 1, where certain of the speed ratio capacities have been omitted.

In both the models described, the retarding horsepower is that absorbed by the converter at full racing. The right-hand curve represents this horsepower value. The working range is from 200 to 300 rpm below engine governed speed and lower. The rapid increase in horsepower absorption with increase in rpm decreases the hazard of overspeeding the engine. Some operators, cognizant of this fact, are permitting drivers to use higher engine speeds on favorable grades.

The retarding horsepower indicates directly the amount of converter cooling that must be provided under these conditions. At first, the requirement seems to indicate an enormous engine radiator will be needed, but when the problem is analyzed, it is found that the solution is relatively simple. The engine radiator requirement is increased slightly, for two reasons: (1) to accommodate a higher average output of horsepower by the engine as compared to its average output when used with a mechanical transmission; (2) to accommodate the power loss within the converter during its function as a power transmission. Normally, a 30% increase in capacity is adequate.

The increased horsepower transferred to heat during the retarding function is accommodated by that portion of the radiator capacity not being used by the engine, since, during this function, the engine throttle is closed and little engine heat is developed. As a matter of fact, the heat from the converter has been found to maintain uniform engine temperatures without shutters during long periods of favorable grade operation. Therefore,

Braking Aid for Big Trucks

W. B. Gibson, Twin Disc Clutch Co.

Excerpts from paper, "Hydraulic Torque Converter—Common-Law Spouse of Heavy-Duty Truck," presented at a meeting of the Detroit Section of the SAE, Detroit, Oct. 27, 1952. (Complete paper will be printed in the 1953 SAE Transactions.)

the solution reduces to providing a heat exchanger of sufficient capacity to transfer the converter heat to the engine water.

Here again, close cooperation between the engine, converter, and truck manufacturers is required to engineer properly the additional requirements along these lines that are surely just around the corner. While the above retarding feature has been made available without additional gadgets or cost, there is reason to question how long the braking capacity will be adequate.

Already, the manufacturers of the single-stage converter have units on test. The problem for them has been complicated by the mechanical design of their units, but they have the brain power and the desire to solve it.

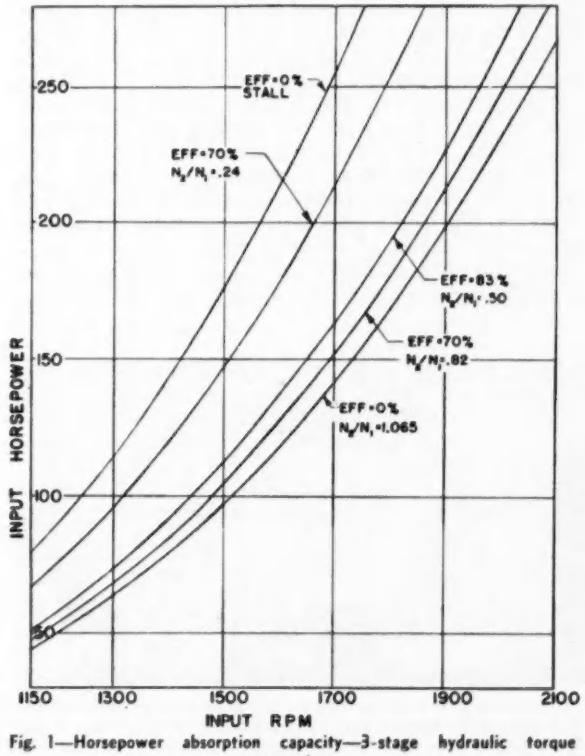


Fig. 1—Horsepower absorption capacity—3-stage hydraulic torque converter

The aim is to cause the torque converter to relieve the service brakes of their load peaks and to provide longer brake life without imposing a major cooling problem on the truck manufacturer. There are hydraulic retarders already available to handle the extreme braking requirements.

The optimum converter performance just outlined cannot be obtained without some help from the engine manufacturer. He has long been accustomed to designing for mechanical transmissions and therefore has shaped his engine torque-speed curve to provide a peak torque rise of from 7 to 10% occurring at about 70% of engine governed speed. The engine torque curve should peak closer to 80 or 85% of engine governed speed and the torque rise should be as high as possible, but a minimum of 15% is required.

The engine manufacturer can also help to overcome the inherent speed lag within the torque converter by the use of lighter flywheels designed to make more use of the WR^2 of the torque converter elements. A more rapid acceleration of the engine from idle or partial speed up to full speed will smooth out the dynamic output horsepower curve of the converter when viewing the overall operating requirements of the vehicle.

The design of the cooling water circuit, including the location of temperature control thermostats, radiator bypass lines, and water circulating pump, must take into account the torque converter cooling requirement. The design must provide for the location of an adequate oil-to-water heat exchanger for cooling the torque converter during both functions of vehicle propulsion and retarding. The location of the heat exchanger should be such as to permit ready access to the engine for daily maintenance and minor servicing. These requirements are not going to be met easily because most changes will have to be made to engines already in production.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Tooling Costs

REDUCTION of aircraft tooling costs is of major importance at this time because of the present trend of aircraft design toward parts and assemblies of a more complex nature. This trend has increased the requirements and complexities of production tools, thereby increasing the cost of tooling.

In regard to tool costs as affected by airframe structural design, it was reported that at Boeing's Seattle plant close coordination between engineering and tooling is of prime importance. If tooling is consulted in regard to parts fabrication problems, it will, in many cases, be beneficial to tooling and production as well as to the overall airframe design.

For example, an assembly that was redesigned according to the recommendations of the tooling department resulted not only in a reduction in the cost of the tooling parts but also lowered the weight of the assembly. This was advantageous from the design standpoint.

In some cases, a change in design would reduce the cost of both the tools and the production parts—in others, it would increase the cost of tooling but, due to the reduced cost of producing parts, the overall cost would be less and, therefore, it would still prove advantageous to change the engineering design. The evaluation of each specific problem is, of course, particularly dependent on the size of the production order.

Engineering tolerances should be more closely evaluated and increased, wherever possible. Tooling costs have been increased as much as 500%, due to a reduction of tolerances. These tolerances should be as liberal as possible and reduced no more than is absolutely necessary.

The new methods of fastening and close tolerances required on holes for rivets and bolts were also said to increase the cost of tooling. It was felt that these items should be kept as standard as possible and to a minimum number of sizes. By so doing, the types and sizes of tools required would be kept to a minimum, thereby reducing tool costs.

It was asked if this closer coordination between engineering and tooling in regard to improved design had reduced the cost of tooling on present-day aircraft. The answer: in spite of this, it definitely had not and that the ratio was still going up. As an indication of this increase, the tooling for present-day aircraft is 50% higher than it was in the days of the B-17 tooling program.

The question that seemed of foremost interest was the type of organization required to control engineering design in relation to tool costs. It was quite apparent that an entirely satisfactory method of handling this problem has not been reached by any of the aircraft companies represented. However, it was pointed out that several companies have established tooling sections to accomplish this work. They are variously known as the master planning group, the experimental tooling group, and the project planner for each particular program.

The Panel was also presented with the following related questions:

1. In order to increase production of the larger assemblies, which would be cheaper, an assembly made up of large pieces or one made up of a number of bits and pieces?

2. Would the same design be used for prototype and production and how does the large piece design tie in with the rate of production?

There were several schools of thought expressed on this subject. One opinion was that the overall cost of both tooling and production would be less if the assembly was made of large pieces and that the same design should be used for both prototype and production and that this would serve as a means of proving out the airframe design. Another opinion offered was that a large piece design could not be justified unless the overall cost including the overall weight reduction in the airframe was considered. The opinion was also expressed that on small orders it would be necessary to continue with the bits and pieces type of assembly; however, on smaller types of aircraft with orders of large quantities, the assembly made up of large pieces could be justified from an overall cost standpoint.

Members of the panel on economics of tooling included (left to right): E. F. Mellinger, Ryan Aeronautical Co., Inc.; C. S. Wagner, Lockheed Aircraft Corp.; C. S. Glasgow, Douglas Aircraft Co., Inc.; Panel Leader B. F. Raynes, Rohr Aircraft Corp.; Panel Coleader B. K. Bucey, Boeing Airplane Co.; R. L. Pollock, North American Aviation, Inc.; G. R. Gordon, Consolidated Vultee Aircraft Corp.; and Secretary R. A. Peterson, Rohr Aircraft Corp.

Can Be Lowered

R. A. Peterson, Rohr Aircraft Corp.

Report of Forum on Economics of Tooling held as part of the Aircraft Production Forum at the SAE National Aeronautic Meeting, Los Angeles, Oct. 1, 1952. Leader was B. F. Raynes, Rohr Aircraft Corp.; coleader was B. K. Bucey, Boeing Airplane Co.

The statement was made that engineering and tooling needed a common system of dimensioning. This was not felt to be too important as long as engineering indicated the high and low limits on their dimensions, and that tooling could then break down the use of this tolerance for production and tool fabrication.

Prototype Tooling Policy

In setting up a prototype tooling policy, consideration must be given to the following points:

1. How many parts will be required?
2. The needs and requirements of production.
3. What does the contract call for as to the type of tools?
4. The interchangeability requirements.

Further, when only a prototype airplane is being planned and tooled, it is the best policy to have a separate facility for engineering, planning, and building, particularly in view of the fact that the labor used in a prototype program must be of the experimental type. Preplanning work in this connection must be done with the engineering department. The project head of planning is responsible for setting up the basic tooling policy, and this policy is, of course, subject to management approval.

There also are several items on the basic tooling program that must be settled. One of these is the determination of whether or not any master tooling should be built, and if so, to what extent; a decision must be reached as to what type and how much assembly tooling is to be built; the least expensive methods and materials must be determined for the assembly tools for the prototype unit, the most commonly used materials being wood and plaster. Optics should be used to set up as many of the tools as possible and planning should determine how many hours are to be used on each assembly—this is called a target time.

The experience of one of the companies shows that, compared to production tooling costs, the X-type prototype tooling costs will appromixate 8% and the Y-type prototype would approximate 24%. Lockheed also feels that it is not economically sound to use any of the X-prototype tooling for production and that only 50% of the Y-prototype tools can be salvaged for use on production. However, Lockheed does salvage its planning. The personnel who plan the prototype follow it on into production.

Douglas feels that it is cheaper to scrap temporary tools and start over for production than it is to try to salvage them.

North American's policy is that, whenever possible, a production-type tool is built for prototype work, but only that part of the tool is completed that is absolutely necessary. It is later refined for production use.

It was asked if Lockheed adhered to its prototype tooling policy once it was set, or if it deviated as it went along. The answer was that, basically, the company sticks to it; however, deviation is sometimes required, due to engineering changes and things of that nature.

Another question was how North American controls interchangeability on the prototype tooling policy it uses. In many cases it feels that it is all right to build masters for the prototype. However, if a master is not built, a good production tool is built for the prototype and a master can then be built from it at a later date.

Another question was in regard to forming, as to whether it would be possible to use lower cost tools on prototype than on production, considering close tolerance and heavy material as dictated by the designs of today. In reply, it was stated that it was a compromise and each case must be considered individually but that, in most cases, the cheaper type of tooling could be used.

Tool Cost Estimates

Tool costs are in direct relation to tooling methods. Tool cost estimates can be divided into two categories:

1. Tool cost standards.
2. Items that would tend to destroy the accuracy of the estimates, such as, the quality of tooling personnel and the cost of subcontracting work.

Tool cost standards are used for estimating and checking the cost of subcontract tools, checking job efficiency, and estimating time on new jobs.

Tool cost estimating for a specific project depends upon whether the company is a prime contractor or a subcontractor. A subcontractor has to consider delivery date and quantity in making a tooling estimate. The tool cost estimates of the prime contractor are often established on the cost per pound of aircraft. This figure will depend upon type of aircraft, commercial or military, the complexity of the aircraft, and so on. Tools are estimated on a pounds-of-tool basis.

The following facts were established about the tool cost estimating policy at Ryan. Specific estimates are made on tools then this estimate is used to check shop efficiency and performance. Ryan

does not make up its estimates from verbal information from engineering but by detailed study of the engineering drawing. The tool cost standards for detail tooling are established by past performance; however, for assembly tools the specific tool has to be estimated. Management at Ryan is sold on the detail tool cost estimates from the cost standpoint because it feels that this improves tool shop performance. Ryan puts the time estimate on the orders that are sent into the shop. Some of the other aircraft company representatives indicated that they did not feel this is a good policy.

On new models, Convair makes up its estimate from a production illustration that shows the production breaks, and so on.

In closing this subject, it was the general opinion of the Panel that there is still a lot of room for improvement in the field of tool cost estimates.

Optical Tooling and Masters

The discussion on optical tooling and masters opened with a statement aimed at clarifying the fallacy that optical tooling eliminates the use of masters. It does not eliminate the use of masters, but it does eliminate a lot of the problems encountered with masters. Optical tooling is a new and useful aid in our efforts to increase the accuracy and reduce the time and cost of our present-day tooling programs. As previously stated, optical tooling does not eliminate masters, however, the large master can be eliminated if optics and small facility masters are used together properly.

All optical tooling systems have one basic point in common and that is the use of a line of sight or optical reference line. The application of this line of sight or optical reference line varies, however. There are four basic optical tooling systems used in the United States today. Briefly, they are as follows:

A system that uses a collimator mounted to the facility tools and a target and telescope to establish the line of sight, the facility tool being adjusted until the collimator is aligned with the line of sight.

The second system establishes the basic line of sight with a collimator and telescope, after this is done the telescope is replaced by a target. A telescope is then adjusted into the line of sight viewing back from the telescope into the collimator mounted on the jig.

The third system establishes a basic line of sight with a telescope and target but uses autoreflection for locating the facility tools.

The fourth system uses a basic line of sight established with a target and telescope. An optical square is adjusted into the line of sight for establishing points and planes in space.

Some of the advantages of optical tooling were brought to light at this meeting. One advantage of optics is that less experienced jig builders can do a more accurate job than was possible in the past with highly skilled personnel and this greater accuracy in the original tool fabrication obviously reduces future jig reworks. Large, cumbersome steel masters are seriously affected by temperature changes, but, by using optics, this type of master can be replaced with comparatively small facility tools and the differences encountered from temperature change greatly reduced. It was pointed out that optical tooling falls right in line with our efforts to reduce tool costs by reducing the amount of floor space required, reducing the number of man-hours, and making it possible to use less skilled personnel for tool fabrication.

The Panel was asked whether the greatest saving was derived from optical tooling in the original set-up or in rechecks. The consensus on this point was that the greatest saving appears to be in the rechecking of the jig, inasmuch as it takes 25% less time to build a jig optically but 50% less time to recheck it. Due to this time saving on jig rechecks, some manufacturers are using optics for periodic checks on jigs that were built by other methods. Not only is there a saving of time in the fabrication of jigs but the man-hours required for building masters or facility tools by the optical system are far less than the man-hours required by the older, conventional method. Examples were cited where tooling man-hours required to build masters or facility tools by the optical system were only 3 to 10% of the hours required for conventionally built masters.

A report on Convair's findings on the tooling dock at Fort Worth indicated that the following facts have been established by its use. A saving of 25% on tool building time can be accomplished by this method in relation to conventional methods. Convair believes that the tooling dock is far superior to any other method for certain types of tools and that many jigs can be built cheaper this way than by optical means or any other method known today. Convair periodically checks its tooling dock with optical methods.

For linear measurement in its optical tooling system, Douglas is using a tooling bar attached to the jig. However, it is felt that the greatest problem confronting the optical tooling system today is linear measurement. To date there has not been a completely satisfactory answer to this problem.

Tool Research and Tooling Methods

On the subject of tool research and tooling methods, it was stated that we are forced into tooling research by the following items:

1. New materials.
2. New machinery.
3. New product design.
4. Economic pressures.
5. Type of production personnel.
6. Need to reduce tool-up time.
7. Shortage of skilled tooling personnel.

It was also pointed out that the objectives of a tooling research program are as follows:

1. Develop the tools to make the part.
2. Develop the tools to make the part economically.
3. Economically produce the tools.

To overcome the problems as listed and to achieve the objectives of a research program, new tooling methods and materials must be developed. One of the new tooling materials that has been developed is plastic. Lockheed Aircraft has done a great deal of work in the development of plastic forming tools. Some of the new tooling methods that have been developed by the aircraft industry are optical

tooling, cheaper methods of building check fixtures, new methods of attaching fixtures, and glass-cloth layouts.

The question on tooling research and tooling methods that seemed to be uppermost in everyone's mind was, how much money is assigned to research, and on what basis. The answer to this problem is that it is handled in various ways. Some companies request a research project fund for a certain number of people plus an additional fund for work done in the regular tooling departments. Another company assigns a certain amount of tooling research each year, regardless of the sales made in that year. In other cases, the cost of tooling development is charged to the contract.

On the subject of tool type evaluation, it was explained that engineering should consult tooling in regard to design problems and tooling should indicate which of several methods is the best.

An evaluation of the cost of tooling must be made on the basis of tool cost per production part. These tool costs can be broken down into two types—intangible tool costs and tangible tool costs. Intangible tool costs would consist of such things as engineering changes. The tangible tool cost factors that can be used in tool type evaluation are:

1. Total number of pieces.
2. Number of pieces per release.
3. Setup and teardown time.
4. Operation cycle.
5. Cost of the tool itself.

It was pointed out further that all of the tools on a production contract cannot be built on time, so, therefore, a selection of those that are considered of first importance must be made. There are standard tool sets available for making tools, but they are not considered very satisfactory because they are too heavy.

From the questions asked, the following facts were developed: The first of these was that the quality of a part ought to be brought into the tool evaluation picture. Secondly, the quantity of parts has to be very high in order to justify even the cheapest type of blank die. North American has no set method for presenting tool-type evaluation data, the planner makes his own evaluation for each tool, although he does have examples to guide him in this evaluation.

Boeing-Seattle planners have a project document giving them the production requirements for tools, and basically they use about the cheapest type of tool that will do the job.

The following formula was given as the means for finding the total cost of a part.

$$\frac{\text{Setup time} + \text{teardown time} + \text{runtime}}{\text{Number of pieces}} = \text{Labor cost per part}$$

$$\frac{\text{Tool cost}}{\text{Number of pieces}} = \text{Tool cost per part}$$

$$+ \text{Productive material}$$

$$= \text{Total cost per part}$$

Measurement of tool shop performance through tool estimates was said to be of vital importance to any manufacturer, whether he produces 100% of his tools or subcontracts a high percentage of them. Some of the reasons given for the importance of measuring tool shop performance through tool estimates were: it provides a basis for forecasting and measuring shop efficiency; establishes a basis for comparison of costs to percentage of completion; provides a comparison for tooling costs with those of other departments, such as, production, engineering, and subcontractors; indicates trends of efficiency; tends to improve the morale of supervision and the worker on the job by providing discussions with supervision at periodic intervals relative to the cost status of each and every project.

It was further pointed out that in the tooling industry today there are two effective cost measuring methods. Method No. 1 is that in which each component is broken down into the number of operations to be performed and an estimate or synthetic standard established. In the second method tools are classed by type, size, and degree of difficulty.

Convair, Forth Worth, uses the second system, although it is not as accurate as method No. 1. The steps necessary to apply a system such as Convair uses are: Divide the various tool manufacturing shops into as many cost center groups as expedient; code each tool by type; classify each tool as to degree of difficulty and size; establish man-hour values for bench or assembly time for each degree of difficulty and size; set up average values by type of machine for machine time on each operation; establish rework standard hours for each type of tool; allow a sufficient trial period for collecting factual data prior to freezing the synthetic standards; create a system for issuing process sheets or job tickets; tabulate the results from the process sheets at the completion of each week of manufacture; then, by dividing the number of standard hours of work produced by the actual hours spent, the percentage of realization of the tool manufacturing group can be determined.

It was cautioned that any type of measuring system must be kept as simple as possible in order not to burden the worker and supervision with complicated systems that might require more time to apply than the merit saved.

At the present time Convair feels that the insufficient degree of accuracy they have found present in their system may possibly be controlled by increasing the number of categories and by the application of more realistic estimates without resorting to operational time studies.

The following conclusions can be summarized from the questions and discussions that ensued:

1. When the shop feels that an estimate is incorrect, it should and does have the right to appeal to the tool planner.

2. No attempt should be made to keep a record on each individual worker as to the amount of time spent on any tool.

3. Estimates need not be adjusted to reflect the class of worker involved.

The report on which this article is based is available in full in multilithographed form together with reports of the nine other panel sessions of the 1952 SAE Aircraft Production Forum. This publication, SP-300, is available from the SAE Special Publications Department. Price: $2.00 to SAE members, $4.00 to nonmembers.

Jet Planes Cost

AIRCRAFT performance is mounting fast, but so are complexity and cost . . . and something has got to be done about it. The situation today can be likened to that of a starving man turned loose in a pantry. We have made performance gains so rapidly that we've lost sight of such other equally important factors as producibility, cost, and ease of maintenance.

What's needed is a completely different approach. As we proceed along the path of aircraft development, decisions should be made on the basis of how much one factor will suffer—not on how much another will gain—if a certain change is made. And before design engineers call the play, they should call production men into the huddle.

One U. S. engine manufacturer had the right idea when he said, "that developing an engine is exactly like raising a child to be a useful citizen. His physical, mental, and spiritual development must all be fostered—not one at a time, but all simultaneously and constantly. Parents do not program the development of a child's personality for his fourth, tenth, and seventeenth years." And so it should be with aircraft and aeronautical equipment. If we are to be effective in increasing producibility and lowering cost, we're going to have to give just and judicious consideration to all factors —from the birth of a project to its completion.

How Things Stand Today

Just how do things stand today? Let's take a look first at the worst possible situation, then consider what can be done to remedy both it and other unpalatable situations.

One British aircraft concern, for example, has a standing rule that development engineers should not discuss their projects with production men. The thought behind this is that the minds of development engineers might thereby become contaminated with the practical aspects of production . . . and design objectives might thus be compromised!

The U. S. approach, as cited by the chief engineer of one of our leading aircraft companies, is better—but still far from perfect. He stated that theoretically it would be proper to have producibility continually reviewed from the inception of a project. However, he felt that since so little time is available the study of producibility in the prototype design must be limited to certain basic features. Included on his list of "basic" features were airplane configuration, arrangement and outline of exterior components, structural arrangement and basic patterns of construction, arrangement and space allocation for internal equipment, controls, wiring, and plumbing. Further refinement than this in the producibility area, he felt, would have to wait until production was under way.

This approach is a compromise between the theoretically desirable continuous consideration of producibility and the British "hands-off" policy. In recent years with models changing constantly to make possible great strides in performance, it's easy to see why this so-called practical approach was used. But it won't do any longer!

Industry May Price Itself Out of Business

Some people might claim that the increased cost of today's planes is justified because of their increased performance. But justified or not, skyrocketing cost poses an extremely serious problem.

For instance, in the very recent past, a new higher performing aircraft was developed which the Air Force desired to procure. However, the unit cost of this plane was so much greater than that of the lower performance plane then in production, the Air Force couldn't afford it. Thus, the Air Force

Table 1—Saving per Year Obtained by Improving Producibility of Plane Parts

Type of Change Made	Savings per Year ($)
Change the wing flaptrack from a machined billet to a forging	87,836
Remove a wing flap screw cover	172,080
Change some angles and clips to forgings	34,171
Change the bomb hoist chain-link adapter from bar stock to forging	31,144
Change type of stiffner for access panel	42,480

Too Much!

. . . Performance is mounting at a fantastic rate, but so are complexity and cost. And it's up to design engineers and production men to get into a huddle and do something about it.

Brig. Gen. Walter G. Bain,
U. S. Air Force; Chief, Procurement and Production, Air Materiel Command

Based on paper, "Aircraft Cost Reduction," presented at SAE Southern California Section Meeting, Los Angeles, Nov. 13, 1952.

had to buy quantity instead of quality because of the very high cost of the quality.

This same dilemma is now approaching the Air Force on a much broader scale. For that matter, aircraft, guided missiles, engines, and electronic equipment are becoming so expensive due to emphasis on high performance that the aircraft industry may be pricing itself out of business!

Not that we can do without performance. We can't! We must have superior weapons or we cannot survive. But we must find ways of obtaining this performance at lower cost. Otherwise, the U. S. Air Force will not be able to buy enough planes to defend the nation.

What Can Be Done

Now let's take a look at some examples of what can be done to remedy this situation. Most of the fertile area for improvement lies in the smaller, more obscure aircraft parts. Typical yearly savings that were obtained by making small changes in one of our aircraft are shown in Table 1.

These changes were just a few of many made to improve producibility after production was rolling. But it would have been far better if they had been made in the early design stages. Not only would we have caught some aircraft that we missed, but we would not have had the expense of scrapping or changing tooling.

Another aircraft manufacturer, by restudying and redesigning his guided missile for production, was able to reduce the cost of the first 225 articles approximately 20%.

In the accessory field we find another example of progress being made. It was found desirable to eliminate a considerable amount of the rough machining necessary on a propeller hub. Study indicated that the piece could be forged to within a fraction of an inch of the finished dimension, making possible a saving of about $100 per hub!

Aircraft Engineers Can Do the Job!

These, then, are examples of what can be done. But we can't stop here. Admittedly, we have made giant strides in performance, but with them have come some very unwelcome guests—complexity and high cost.

Speed of planes, for example, has just about tripled in just five years, but so has cost! That's because controls for operating these speed demons have become a bewildering maze of wires, radio tubes, and electronic gadgets that transcend even Buck Rogers' wildest dreams.

But the aviation industry is not powerless to cope with this situation. With its approximately 400,000 engineers, it's well equipped to accept the responsibility for producibility and cost to the degree that it accepts the responsibility for performance. It's up to these engineers to rationalize the many conflicting requirements and arrive at suitable compromises. And they must do this from the inception of a project—not later when certain avenues of solution are closed.

In the interest of the taxpayer's dollar . . . equipping the Air Force with sufficient aircraft . . . and continuing production lines in aircraft factories, it is sincerely hoped that aircraft engineers will accept this challenge. Only by so doing can we lower defense costs and safeguard the true objectives of the United States.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

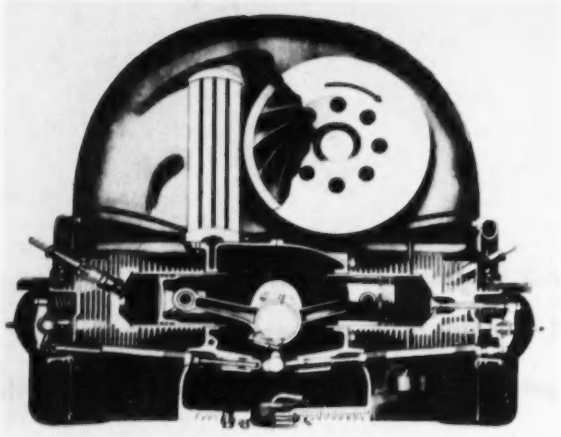


Fig. 1—Arrangement of the cooling system in the Volkswagen air-cooled engine

How to Cool and An Aircooled

Ludwig G. Boehner, Chief Engineer, Volkswagen Co.

Based on paper, "The Volkswagen Aircooled Engine," presented at SAE Annual Meeting, Detroit, Jan. 13, 1953.

SINCE its inception in 1934, the 4-cycle, 4-cyl, aircooled engine used in the Volkswagen passenger car has undergone many changes. Among other things, displacement and specific power have been increased, further complicating the job of engine cooling and noise control. Development work, however, has eliminated to a great extent these disadvantages of an aircooled engine as compared to a watercooled one.

Measures taken to improve engine cooling were intended (1) to prevent overcooling in winter, especially on downgrades; and (2) to equalize temperatures of the cylinders and cylinder heads, prevent local temperature peaks, and overheating of the engine in general. And they did!

Foremost component in the system that brought about these results was a thermostatic control that works on the throttling principle. This control is structurally simpler, cheaper, and more foolproof than other types. And its comparative inefficiency is a minor consideration in view of the low head of cooling air involved.

Before discussing how this control is built and what it does, it might be well to point out that an aircooled passenger-car engine must have a controlled cooling system. That's because if a cooling system were designed for adequate cooling at full load, it would overcool the engine at part load . . . and it's in this range that most vehicle service takes place.

Fig. 1 shows the arrangement of the aircooling system. The radial fan is mounted above the opposed cylinders and pistons. The impeller, which runs at twice the speed of the engine, forces cold cooling air through two asymmetrical scrolls into the cooling-air passages of the cylinders and cylin-

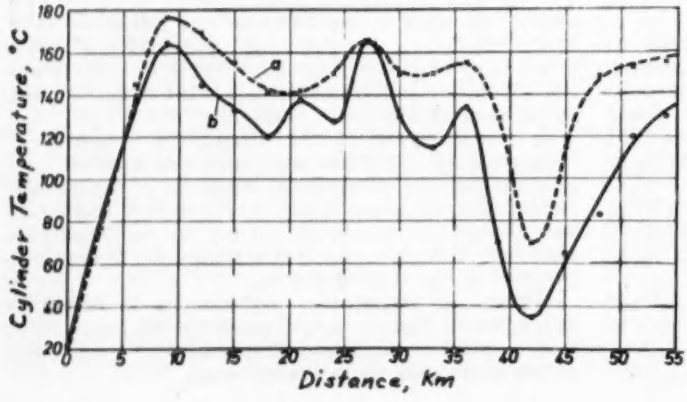


Fig. 2—Higher cylinder temperatures are possible with a thermostatic-controlled aircooling system, curve a, when the vehicle is driven over a mountain road in −5 C ambient temperature. Note that cylinders are cooled to a critical wear temperature (35 C) on a steep downgrade in the car without cooling-air control, curve b, but they fall to only 70 C (outside the critical wear zone) in the car with the thermostatic control

Quiet Car Engine

à la German Style

der heads. The air first passes through an oil cooler on the left. The heated air is collected in ducts below the cylinders . . . and is either exhausted to the rear or passed forward to heat the passenger compartment.

The thermostat is located in the outlet duct under the right-hand cylinders. A simple compression member passes up from it between the two cylinders. This is linked to a lever operating the throttling device located in the fan intake.

The throttling ring is so shaped as to provide a baffle surface for the incoming air. In the closed position it confines admission of cooling air into the impeller to a narrow slit. This slit is deliberately made wider than required for safety alone to provide the necessary hot air, even in the closed position, for heating the passenger compartment and defrosting the windshield.

The effectiveness of this control system is illustrated in Figs. 2, 3, and 4. Fig. 2 shows comparative results of test runs at – 5 C ambient temperature on a mountain road with steep up and downgrades. The plotted temperature is that at the top of cylinder two, on the side away from the cooling-air intake. Comparison of curves a and b shows the gain in temperature due to the control. For example, while the cylinder is cooled to 35 C without the control on a very steep downgrade, it falls only to 70 C with the control. The curves also show that in case b, about 4 km are traversed in the critical wear zone between 35 and 70 C, while this zone is not entered in operation with cooling control.

Fig. 3 shows cooling curves during a downgrade run at an ambient temperature of 2 C. In this case, curve a (with control) is about 13 C, or 24%, above curve b (without control) at the end of the grade.

Since this temperature gain seemed rather small, an investigation was made to find out what gain would be possible with the cooling system shut off completely, for example, with the impeller stationary. As curve c shows, the improvement over the throttled control (curve a) was surprisingly small. It was only when the throttling ring was also closed that the very gradual cooling-off shown by curve d was obtained. This means that the cooling-air throttle is highly effective even with the impeller

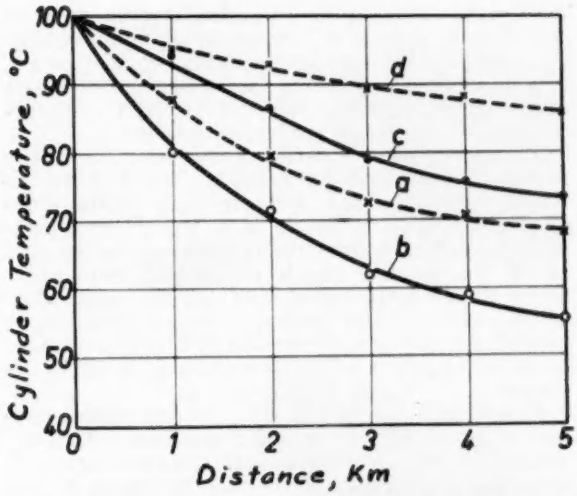


Fig. 3—This shows what happens at 2 C ambient to cylinder temperatures during a downgrade run in a car (a) with thermostatic cooling-air control, (b) without cooling-air control, (c) with the cooling-air throttle open and the impeller stationary, and (d) with the cooling-air throttle closed and the impeller stationary. Important thing to note here is that the cooling-air throttle is highly effective even with the impeller stationary

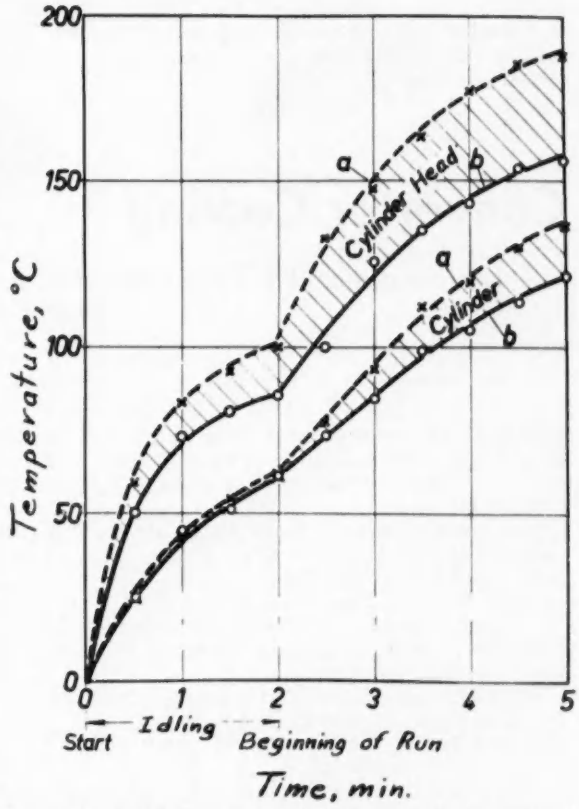


Fig. 4—Here's what happens to cylinder (lower set of curves) and cylinder-head (upper set of curves) temperatures when an aircooled engine is started in an ambient temperature of 0 C. In case a, the vehicle is equipped with thermostatic cooling-air control. In case b, it is not. Note that after a 3 min run, cylinder temperatures are 15% higher and cylinder-head temperatures 22% higher in the engine equipped with cooling-air control

stationary. Further investigation showed that, in this case, temperature differences set up a cooling-air current in the opposite direction to that of the impeller. In other words, air entered the outlet ducts, passed through the cylinder and cylinder-head fins, and left by the impeller inlet.

Another point of interest is the behavior of the engine when started cold (at 0 C). Fig. 4 shows the rise in cylinder and cylinder-head temperature when starting on the level. Here the effect of cooling-air control is less pronounced, since an air-cooled engine will reach operating temperature faster than a watercooled one. All the same, after a 3 min run with the control, there is a temperature gain of 15% on the cylinder and 22% on the cylinder head as compared to the same engine without the control.

A decisive factor in reliability of this cooling system is the durability of the thermostat. This development offered considerable difficulty before it was possible to attain a life of over 100,000 strokes at temperatures up to 120 C. Even so, it is necessary to watch for an occasional thermostat leak. This breaks the vacuum and equalizes it with the outside air pressure, so that the thermostat expands as far as the holder permits, opens the throttle ring, and admits a maximum of cooling air. This tendency is further assisted by the torsion spring on the operating shaft. *Thus a defective thermostat will not in any way interfere with the function of cooling.* This is not true of some watercooled engines.

Other changes helped to bring the engine closer to the noise level of watercooled engines with their noise-dampening water jackets.

Use of "autothermic" pistons, which permit slight structural play without seizing, reduced piston noise. Reinforcing ribs increased rigidity of the powerplant casing. And sound dampeners cut transmission of sound through solid parts.

Fan speed is kept as low as possible, since noise increases with increasing air speed. This, in turn, requires ample cooling surface on both cylinders and cylinder heads, so that lower air speeds will suffice.

The question of whether axial or radial fans are better cannot be answered at present. Axial fans generally require high speeds, since there is usually not enough room for a sufficiently large diameter. A radial fan, of course, of the same diameter, will reach a given delivery head at a lower speed. At the same time, however, the efficiency is lower than in the axial fan at certain speeds. Another factor in selection is that the radial fan admits of further improvement, so that the axial fan is not necessarily to be preferred in all cases.

In short, systematic detail work is necessary to reduce the noise level of aircooled automotive engines so that they will ultimately be on a par with watercooled engines in this respect.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Converter Cooling . . .

. . . can be direct if torque converter output is low enough. Otherwise, a cooler better be added.

Based on paper by **R. C. Zeidler,** Long Mfg. Division, Borg-Warner Corp.

DIRECT air cooling for torque converters is the cheapest and simplest. The converter and installation should be designed to get the most out of direct cooling.

The greatest benefit from direct air cooling will come from giving careful attention to directing the air in and out of the bell housing. The inlets, of at least 10 sq. in. total area, should direct the air to the inner diameter of the blower attached to the converter. This should be screened to keep out large foreign particles.

Sometimes it's difficult to shape the bell housing at this point. In this case, a stamped metal baffle attached inside the housing will help a lot to reduce air recirculation.

The outlet openings should have a much greater area than the inlets. They should be located forward of the blower's outer edge. To help air flow and cooling, the housing should have a volute shape with the air leaving tangentially, similar to the standard centrifugal fan.

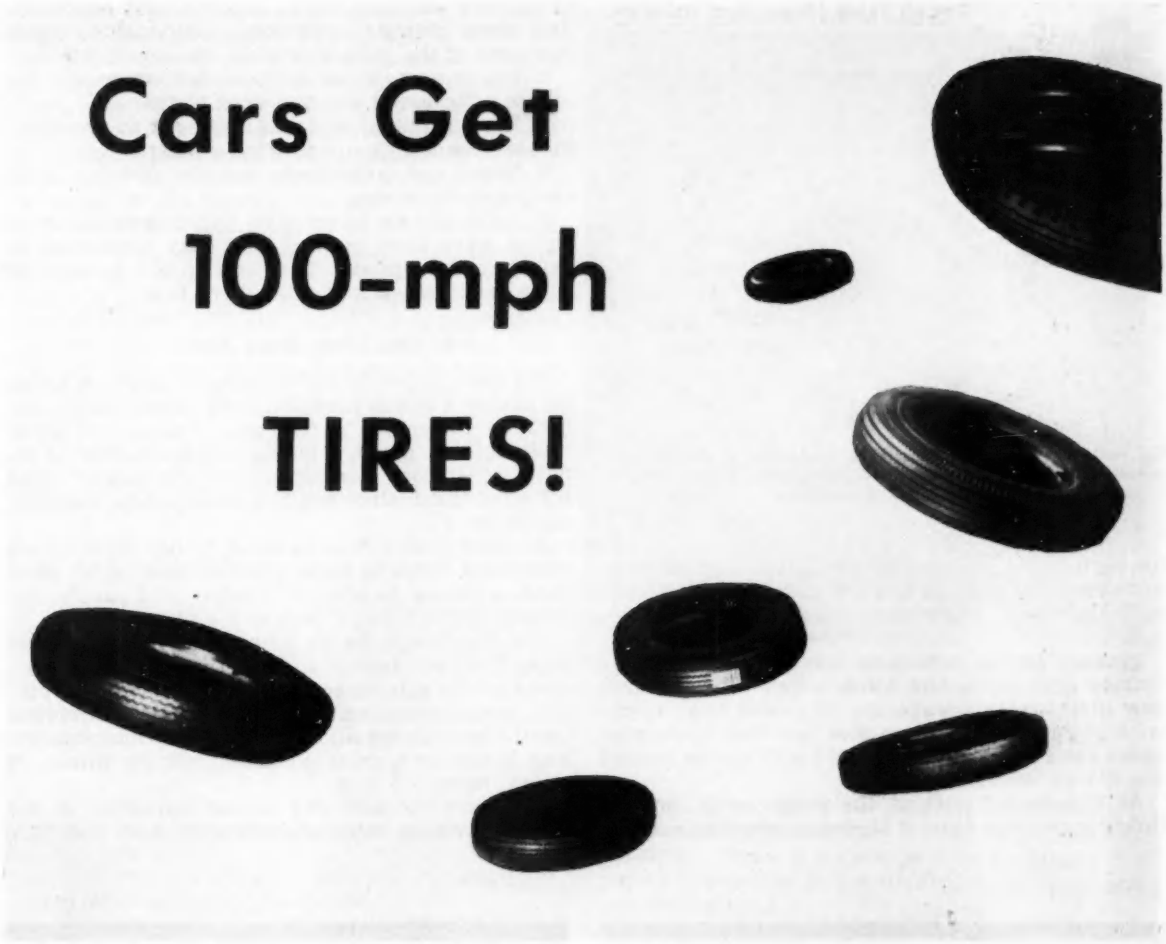
For vehicles subjected to frequent starting and operation in the lower speed ratios of the converter, providing ample cooling is more of a problem.

The converter manufacturer should be able to analyze the installation and tell whether a cooler is needed. Approximate cooler size can be calculated in advance if certain test data on past installations and facts about the new one are available.

Most economical cooler seems to be the oil cooler of the oil to water type, with the full flow of the engine cooling-system water going through the cooler. It takes less space and is more readily fitted to installations. The regular radiator has to be able to handle both maximum engine demands and oil cooler needs. If the present radiator can't do that, it will have to be increased. An oil cooler having its own air flow is generally prohibitive because of space limitations.

(Paper "Let's Put in a Torque Converter," was presented at SAE Chicago Section, Dec. 11, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Cars Get 100-mph TIRES!



J. J. Robson, Firestone Tire and Rubber Co.

Based on paper, "Tire Safety at High Speeds," presented at SAE National Passenger Car, Body, and Materials Meeting, Detroit, March 3, 1953.

SKYROCKETING horsepower of passenger cars continues to keep tire men working full time developing tires that are safe to use at the full performance of these power-packed vehicles. Not that tire manufacturers recommend high-speed driving. They don't. But with production cars capable of 100 mph, tire men know it's up to them to supply tires that provide (1) safety protection against blowouts, and (2) adequate stability and cornering power.

Each of these requirements has received special attention. First, let's consider what has been done to improve safety protection against blowouts.

Here the primary problem is heat. At 100 mph, tread temperatures reach 280 F almost instantaneously. (See Fig. 1.) And this is the temperature range in which rubber vulcanizes or, conversely, devulcanizes with loss of strength and adhesion!

To make matters worse, a phenomenon known as traction wave becomes apparent at about 100 mph. This is a distortion of the tread and body which causes severe stresses in the tire, thereby contributing to the temperature problem.

Traction wave is readily shown by photographs of a tire running on a perfectly smooth laboratory drum. A tire run at 90 mph doesn't seem to experience it. But at 100 mph, the same tire shows a definite distortion where the tread leaves the drum. (See Fig. 2.) And at 110 mph, the tread distortion becomes very pronounced. (See Fig. 3.)

Obviously this high-speed distortion causes unusual flexing and severe stresses in the tread region of tires. This, in turn, aggravates localized temperatures in tread areas and builds up high shear values between the tread and body of tires.

Here, then, was a clue to the improvement of tires

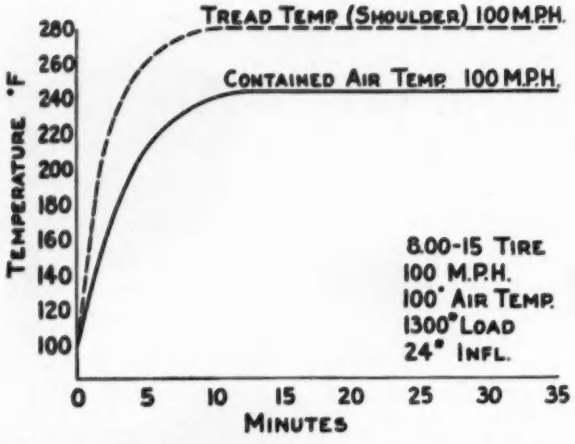


Fig. 1—At 100 mph, tread temperature reaches 280 F almost instantaneously. And this is the temperature range in which rubber vulcanizes or, conversely, devulcanizes

for high-speed service. If the amount of traction wave could be reduced and the adhesion of tread to body increased, better high-speed tires should result.

Traction wave reduction was accomplished by making changes in tire construction. Fig. 4 shows how little traction wave the improved tire experiences. Put another way, the new tire undergoes about the same distortion at 110 mph as the former one did at 100 mph.

As the second part of the program to improve safety protection against blowouts, material makeup of the tire was changed to improve heat resistance and bond between individual components. Here are some of the more important changes made:

1. Use of new rubber compounds that greatly increase adhesion of tread to cord body.
2. Dip on individual cords improved to provide a greater bond with surrounding rubber.
3. Tread and body stocks compounded for high-temperature service.

In addition to direct tire improvements, other things have been learned that may contribute to safety at high speeds. They add up to a good set of rules to follow—if you must drive fast.

If You Must Drive Fast . . .

For example, using higher inflation pressure helps. By adding 4 to 6 lb pressure, both temperatures and traction wave can be reduced. This is not to be interpreted as a lack of confidence in established inflations. It does, however, afford a means of relief for hard-taxed tires working under their toughest condition.

Another good idea is to break in new tires before subjecting them to high-speed service. This gives them a chance to equalize stresses and gain initial growth before being driven at top speed.

It's also desirable to move into top speeds by steps, that is, operate a short time at a moderate speed before going into wide open speeds. This permits tires to establish a proper heat balance between tread temperature and contained air temperature. The result is normal pressure buildup which, of course, helps the tires.

Now let's consider the second objective of tire men—providing adequate stability and handling

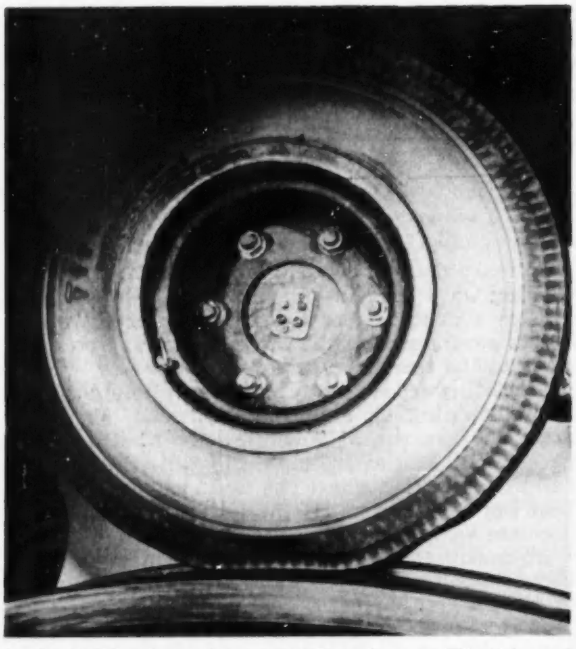


Fig. 2—At 100 mph, traction waves begin to show up. This high-speed distortion causes unusual flexing and severe stresses in the tread

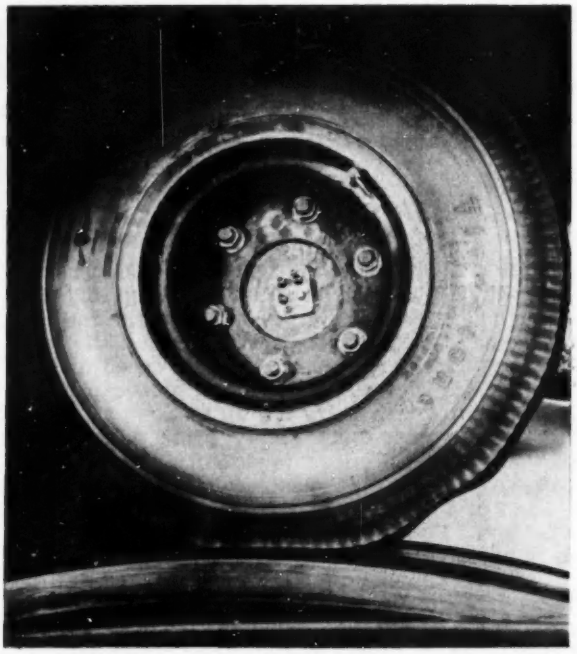


Fig. 3—At 110 mph, tread distortion becomes very pronounced

for quick and sure response at high speeds.

It's almost impossible to document what has been done, but steps have been taken to improve stability. In this case, we face the problem of what is good for stability is poor for ride. Nevertheless, tire engineers have been able to make adjustments in their product that provide a real gain in high-speed handling. In this connection, the 4 to 6 lb extra inflation is very worthwhile, since additional pressure reduces lateral tire deflection and helps increase stability.

In conclusion, tire men do not recommend or advocate high-speed driving. But it is felt that something important has come out of their work to develop tires for high speeds. For it is obvious that if a tire is safer at 100 mph, it is also safer for normal speeds.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Based on Discussion

Comment: It's possible to inject about 4 oz of water into a tire and take advantage of the added vapor pressure created by heat given off during fast runs.

Question: Does the traction wave contribute to front-end instability?

Answer: Yes. There is a tendency for the front tires to skate.

Question: Does the traction wave occur on both front and rear tires?

Answer: We don't know. However, it wouldn't seem to make much difference.

Fig. 4—Changes in tire construction reduced traction wave at 100 mph almost to the vanishing point

Question: What effect do tubeless tires have on high-speed performance?

Answer: There is a little gain in a tubeless tire since it provides better thermal conduction and convection.

Dropping Planes . . .

. . . in the laboratory gives designers advance notice on: what landing gear will and won't do, how much punishment plane structures themselves can take.

Based on paper by **J. W. Gaines and F. V. Wagner,** North American Aviation, Inc.

FOR many years, complete airplanes have been drop tested in the laboratory to determine the adequacy of the landing gear shock-absorbing system and the overall strength of the installation. It has never been conceded that a drop test is in any way a duplication of a typical landing. Nevertheless, it serves a very useful purpose in that airplanes so tested usually perform satisfactorily in service.

While at first drop testing was confined to small, single-engine planes, now large, multi-engine airplanes are drop tested, too. Here, for example, is the test procedure for drop testing the North American AJ-1, a three-engine Naval attack bomber.

Prior to the drop itself, the AJ-1 is properly ballasted for all missing items of equipment, useful load, and so forth. Following this, the plane is hoisted until the wheels are just clear of the ground. (See Fig. 1.) Mechanics then install belts over the wheel-spinning mechanism and adjust the wing-lift mechanism.

Just prior to the drop, the flexible cable between the wing-lift air bottle and the airplane is disconnected and unwound to prevent kinks from occurring. This is important for smooth operation of the wing-lift mechanism.

Guide lines are used to hold the plane while the

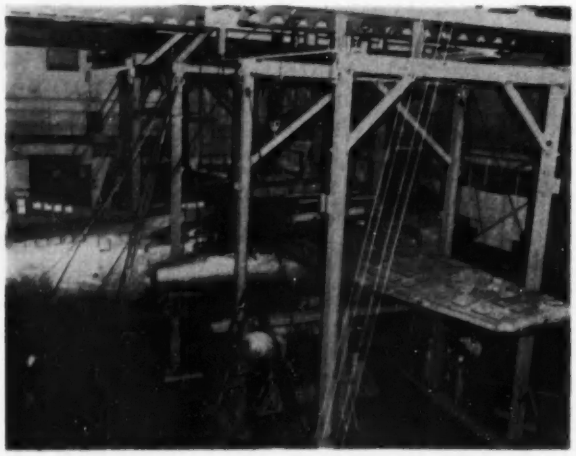


Fig. 1—View of hoisting and wing-lift structure

wheels are spun to the desired speed. (For drop-test purposes, the wheels are spun in the reverse direction to induce drag loads commensurate with an actual landing.) Next the guide lines are slackened to give the airplane complete freedom of motion during the fall.

The plane is now ready for the test. A warning bell sounds! Cameras start to roll. And as the test engineer throws the master switch which sends an electric current to the quick-release mechanism, oscillographs, and control panel, the plane falls freely to the dynamic platforms below. Upon impact, the wheels are brought to rest in only a fraction of a revolution.

Immediately after the drop, the oscillograph records are processed for immediate evaluation. Inspection crews instantly go to work checking all vital operations of the plane and test instrumentation for damage. Meanwhile engineers inspect the structure for possible damage, and measure the compression strokes of the landing gears, drag-load dampers, and other devices where space measurements are important.

(Paper, "Drop Testing A Large Airplane," was presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 2, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Gas Turbine Design . . .

. . . capable of meeting both military and civil requirements is a possibility. If successfully achieved it might stretch the defense dollar.

BASED ON PAPER BY **R. T. Holland,** General Electric Co.

DESIGNING for lower operating cost without jeopardizing the combat effectiveness of aircraft equipment would seem to be one way to stretch the defense dollar. To this end it would be desirable if a powerplant could be designed having characteristics compatible with civil and military requirements. There is reason to believe that noncombat military and civil requirements can be made compatible and that designs which serve them can be given characteristics desirable for combat use by operational techniques without major design changes.

The major difference between combat military and civil operation exists in the characteristics of durability and cost, whereas the economics of noncombat military operation lies somewhere between combat and civil. It is suggested, therefore, that we optimize arbitrarily on the characteristics associated with noncombat military operations. To this goal the following concepts are suggested:

To enhance durability and reliability of the gas turbine with attendant lower operating costs, requirements for high quality control should be reduced, and reduction should also be made in the number of parts requiring high quality control.

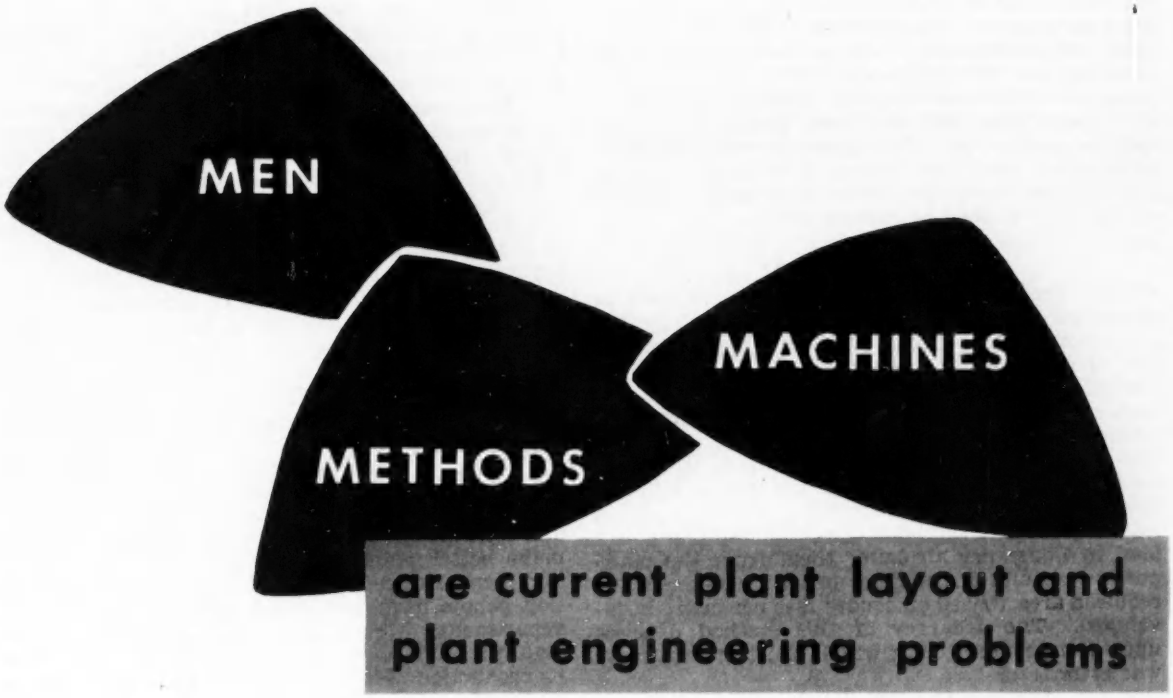
Process selection should be employed, that is, those processes should be favored which introduce a minimum number of operations.

Foreign object damage to axial-flow compressor blading is the most prevalent cause for premature removal, hence, special attention should be given to reducing this type of damage. If this damage is successfully avoided, the next consideration is to reduce blade failure due to fatigue.

Since deterioration and failure of hot gas parts are most responsible for premature engine removal and overhaul, design and operation need examination to see how durability and reliability as well as low operating cost of these parts can be achieved.

In a balanced control system design, the quality control requirements of the components should be inversely proportional to the desired reliability. Also, the component should be limited to functions within its own assigned area. The objective of this concept would be gained, for example, with a control system which eliminates high quality control components from participating in the controlling functions during take-off, when the highest degree of reliability is needed.

Reliability cannot be discussed without including safety, hence, it can be said here that the usual principles of safety should be applied diligently. (Paper, "Differences in the Design and Operation of Military and Commercial Transport Turbine Engines," was presented at SAE Annual Meeting, Detroit, Jan. 15, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).



are current plant layout and plant engineering problems

K. R. Waltz, Douglas Aircraft Co., Inc.

Secretary's report of Panel on Plant Layout and Plant Engineering held as part of the Aircraft Production Forum at the SAE National Aeronautic Meeting, Los Angeles, Oct. 1, 1952. Panel leader was W. A. M. Burton, Douglas Aircraft Co., Inc., and the coleader was H. W. Linton, North American Aviation, Inc.

HOW to get qualified people, how to decide which layout method is best, and what to do about preventive maintenance were the leading problems discussed.

The trend in techniques of layout is toward better preparation methods; toward acetates and overlays; and toward the use of three-dimensional models for detailed planning. The importance of better methods of presentation for selling layout planning to management and production supervision focused greater attention on this phase of plant layout.

Careful planning is required if preventive maintenance is to be handled with the least interruption of production. When production schedules are critical, it is sometimes necessary to provide standby machines to avoid losing time during overhaul.

The economical approach to a preventive maintenance program is systematic inspection to locate incipient trouble. Records show this kind of maintenance to be cheaper than maintenance on a breakdown basis, when machine down-time is considered as part of the cost.

Preliminary Layout Planning

First steps in planning a layout are taken when the company makes a proposal to its customer, establishing the model to be manufactured, the production rate, and the price. Based upon this skeleton information, the plant layout and methods people establish space requirements and prepare an intial block layout of fabrication, assembly, office, and materiel storage areas. This initial block layout then goes through a refining process as production planning progresses and decisions are made regarding the engineering breakdown of the airplane for efficient producibility, the proportion of fabrication and subassembly work to be subcontracted, the special methods and machinery necessary to meet unusual production problems, and the types and amount of tooling to be used.

During all this preliminary planning the plant layout people must work in close coordination with all other groups involved in planning for production of the new model. These groups include: engineering, tool design, contract administration, scheduling, time and method study, production department supervision, and plant engineering. Plant layout people sometimes suggest changes in the engineering breakdown of the airplane and negotiate with the engineering department to get these changes made when an important reduction of a difficult plant layout problem would result.

Early preplanning for future production is usually done by a separate group of seasoned planners. This separate group is usually under the supervision

of the plant layout department, although it is sometimes a committee composed of members from contract administration, tooling, engineering, and plant layout. The group makes flow diagrams, determines what items should be subcontracted, what special equipment and machinery (major items) are required, and so on. The block layouts and other information are then turned over to the regular plant layout group for detail work after approval of the general plan by management.

Plant Layout Yardsticks

There are several yardsticks that can be used in determining area required when only sketchy information, such as weight and general configuration of the airplane, is known.

Some manufacturers have established, on the basis of past experience, a factor of square feet per pound of airplane produced per month. So, for a first aproximation of the area required, it is only necessary to know what proportion will be built on the site (in pounds per month). Others apply a learning curve to establish the estimated manpower load in hours per airplane; then, from the manpower load and the number of shifts planned, the required area (based on square feet per man) is developed. The accuracy of this method depends upon the accuracy with which the learning curve was estimated.

Square-feet-per-man yardsticks are usually set up by function, such as assembly, fabrication, office, and warehouse. These yardsticks vary a great deal and are hard to establish because of the many variables that affect the area utilization in present-day production of aircraft. Programing of production is difficult because of frequent changes in production rate. Rate of production affects utilization—a higher rate usually permits better utilization. Schedule changes therefore upset utilization planning, making changes necessary in the proportion of subcontracting, and so on. Wartime utilizations are hard to attain now because parts are harder to produce, airplanes are larger or more complicated, and installations are much more complex. Most companies have worked out yardsticks for area planning that are satisfactory when they know what to shoot at, but the current state of flux in the industry often upsets the applecart. Planned schedules may fall behind because of frequent engineering changes, and the new complexities of modern aircraft conspire to invalidate yardsticks based on past experience. In general, utilization varies from 50 sq ft per man for office areas to 300 or more for assembly areas.

Wanted: Qualified People

Most training programs are still being developed to meet the need for capable personnel in the plant layout field. Most companies have some sort of training program in operation. These are some of the methods in use with varying degrees of success:

1. Make up a manual that establishes and illustrates all current standard plant layout and plant engineering methods and practice. Then, set up a series of lectures based on this manual to instruct new personnel.
2. Make use of models to illustrate specific layout problems as they arise and use seasoned layout people to illustrate the solution of these problems to the new people. This is a sort of learn-as-you-earn technique successful for on-the-job training.
3. Use specialization of plant layout assignments to intensify and shorten the on-the-job training period, that is, separate plant layout assignments from equipment and facilities analysis assignments until the new people are capable of handling the combination assignment. (This can lead to coordination problems between the two types of assignments when both apply to the same project.)

Many men from the ranks of production supervision have made a successful transition to plant layout work. The problem is to find people with enough perspective to develop the overall view of the plant layout man. The tendency is to emphasize shop too much and to overlook the details of good layout, that is, utilities, services, lighting, and the like. It is important to select men with a foresighted attitude, who are able to do a good selling job, because of the importance of selling plant layout to management. Seasoned production men make better plant layout men than new production men. During slack production periods production people have been transferred to plant layout departments, where they have helped with the planning of layouts for new production programs. As production picked up, some of these went back to production departments, where they did a better job because of their new understanding of plant layout problems, and others remained in the plant layout department to become successful plant layout people.

One company makes use of a management selection test, which shows what aptitudes a man has for work within the plant layout group. Production people with enough background to take the test are selected for plant layout work in this way. Others have contacted colleges and other industries in search of a useful aptitude and psychological test, only to find that none can say the tests have been successful enough to be dependable.

Attempts have been made to survey graduating classes of universities to locate people interested in careers in plant layout and industrial engineering, with but mediocre success. The competition for the good people is too great and the rates of pay expected too high. Many of those who do accept jobs quit after two years or less for higher pay. A plan which has worked better for some is to hire summer help from junior classes in universities, then to allow parttime work and leaves on special status to finish school. By special arrangement, some work three or four hours per day until they finish the last year. This plan has resulted in the development of well-trained people for the field, who have been exposed to the work long enough to know what its problems and opportunities are.

Another untapped source for plant layout–plant engineering people may be the aeronautical engineering department, where young architectural engineering graduates may be found working as aircraft designers or draftsmen. A system of notifying plant layout–plant engineering of such people who want to transfer has resulted in some very successful conversions.

Sometimes there are engineers bucking rivets in the shops, so an occasional combing of personnel records is recommended.

Acetates and Scale Models

A survey of the aircraft industry in Southern California indicates that most use fir-tex layout boards and make initial layouts with scale cardboard templates held to the board with map tacks. These layouts are then transferred to paper either by draftsmen or photographically for use by the shop in executing the layout. In an effort to reduce drafting time required for the reproduction of layouts, some are experimenting with transparent acetate prints of the building outlines, upon which transparent templates are overlaid using two-sided transparent adhesive tape. This is the original layout, and as soon as it is complete it can be reproduced on a blueprint machine in the usual way. This method provides a means for planning as well as duplicating the layout, and eliminates the cost and time loss of drawing the layout on vellum. Original resistance to this method by the layout men disappeared in about a year, for by then they had developed proficiency in the art of handling the adhesive templates.

In regard to three-dimensional planning, a complete, three-dimensional layout of an 80-acre plant proved to be very expensive but highly useful in planning the conversion of the entire plant from automobile to aircraft production. This layout has been valuable for the training of unskilled layout people in initial planning methods.

Smaller plants in the same company use three-dimensional layouts in a limited way because of the great expense. Permanent three-dimensional layouts are made only of those departments where frequent layout changes and greatest layout problems are anticipated. The problem of selling plant layout planning to management and to production supervision is very much easier and more effective with three-dimensional layouts. It is hard to evaluate the cost saving in such selling use, but much time can be saved.

A modified type of three-dimensional template has been tried with good success as a compromise between flat template and detailed scale model. These have been made of plastic and use one end to show overall height of the equipment, otherwise they are similar to two-dimensional templates.

The use of three-dimensional layouts promotes three-dimensional thinking, which is necessary to all good layout planning. Most layout errors result because the thinking has been in two dimensions. Machine travel, overhead clearance, lighting, and use of overhead storage are some of the things apt to be overlooked unless three-dimensional thinking is used.

After the initial planning is completed, the three-dimensional layout is kept as nearly up to date as possible. Some who use this method still rely on drawings for small changes in layout and only revise the three-dimensional layout when large areas have been changed.

Much more interest was shown in three-dimensional techniques this year than last, possibly indicating a trend toward more extensive use of this method. Several expressed the opinion that three-dimensional layout is used more extensively by eastern industries than in the west, and that noticeable improvement in the competitive standing of some of them has been a direct result.

No accurate means have been found for evaluating modern layout methods in terms of dollars and cents, but most discussers felt that the better results obtained by the use of three-dimensional models for the solution of complex layout problems and for the presentation of hard-to-sell proposals to management are well worth the extra cost. More "glamorization" of plant layout is needed in order to improve the quality of the service a plant layout department performs for its company. The payoff results from better customer relations and a clearer understanding of layout by management and production supervision.

The use of symbolic tapes, transparent overlay charts, and colored perspective drawings to help present layout plans to management has greatly reduced the selling time, even though the actual layout planning may not be any better than before these methods were used.

The use of color in layouts has been extended to the shop, where use of a well-planned color scheme reduced absenteeism and improved general plant

Plant layout and plant engineering problems were discussed by a panel consisting of: (left to right) R. Swonk, Lockheed Aircraft Corp.; Secretary K. R. Waltz, Douglas Aircraft Co., Inc.; Panel Leader W. A. Burton, Douglas Aircraft Co., Inc.; Panel Coleader H. W. Linton, North American Aviation, Inc.; R. L. Pleski, Kaiser Mfg. Co.; and R. B. Parkhurst, Hughes Aircraft Co., Inc.

housekeeping by promoting employee pride in surroundings. Color dynamics are profitable.

About 60% of the layout groups represented use ¼ in. to the foot most, while the balance use ⅛ in. to the foot most. The ¼ scale requires layout boards and prints too large to be convenient when planning an entire large building, but ⅛ scale shows too little detail for good execution of layout changes of smaller areas. Most use both ¼ and ⅛ scales, depending upon the amount of detail required.

Making a Layout Work

A layout can be made to function properly only if production supervision is interested in seeing that it does. First, sell them the new layout, get their cooperation in working out the knotty problems, get their approval by signature on the layout drawing, then place the responsibility with shop supervision for making the layout work as planned. Most layout departments assign an area layout man to watch layout rearangements in progress to catch errors and suggest improvements to ensure that the resulting layout can do the job planned. In some cases estimates are made of the cost of the product before and after the rearrangement to measure the improvement. This emphasizes the importance of a time study group as a tool to proper operation and evaluation of a layout

Maintenance Organization

For the purpose of discussion, the following breakdown of the maintenance organization of a Southern California aircraft plant was made:

1. Construction department:
   (a) Buildings and installations.
   (b) Rearrangements and utilities.
2. Process control department:
   (a) Plating, heat-treat, and so on.
   (b) Incoming testing of materials.
   (c) Maintenance of control instruments.
   (d) Maintenance of hydraulic equipment.
   (e) Radar test group (test equipment).
3. Equipment maintenance.
4. Functional test equipment and manufacturing aids fabrication.
5. Special projects:
   (a) New plant construction, and so on.

This organization differs in several respects from the usual.

The quality control department establishes the specifications to be met, then the process control department sees that these specs are met, both in the operation of processing equipment and in the inspection of incoming material.

Equipment engineering was included in this organization at one time, but it is now split off as a separate plant engineering group. This group decides when to replace equipment and recommends the type to buy.

Only emergency purchasing is handled by the maintenance department; all routine purchases are routed through the purchasing department.

Except for the inclusion of the processing control department, this organization is typical of the usual maintenance organization. In general, the plant engineer also controls the plant engineering design section and often also the plant layout and methods section. A composite skeleton outline would look something like this:

Plant engineer:

1. Plant layout and industrial engineering.
   (a) Layout planning.
   (b) Machinery and equipment ascertainment and procurement.
2. Plant engineering design.
   (a) Design of plant equipment and installations.
   (b) Design of buildings and building modifications.
3. Facilities control.
   (a) Plant equipment receiving, warehousing, records, identification.
   (b) Maintain records of accountable property.
   (c) Process procurement paper.
4. Maintenance.
   (a) Electrical.
   (b) Mechanical.
   (c) Carpentry, painting, and labor gang.
   (d) Plumbing and sheet metal.
5. Services.
   (a) Transportation.
   (b) Plant cleaning.

Buying New Machinery

If maintenance costs get too high, according to the maintenance record for a particular machine, the production foreman is notified and a joint request for replacement is filed by maintenance and production.

New machinery may be requested by any department (tooling, engineering, production, plant engineering.) These requests are screened through an equipment engineer, the methods group, then through a committee of superintendents, operating supervision, and so on.

Final approval of the purchase comes from top company management, usually the vice-president, if the machinery is company owned; or from the Government (Air Force, Navy, and so on) if the machine is to be purchased under a facilities contract.

In some cases company-owned machinery requirements are predicted a year at a time, on a budget basis, by solicitation of using departments, by studies of new developments, and so on. This prediction establishes the annual budget, then a specific budget by item for three months in advance is kept active as purchases are made. Others handle items separately as they come up. In most plants operating under facilities contracts an estimate is made at the start of the program and a list of the capital equipment submitted as a contract appendix to the government agency (such as Air Force, Navy, and A.E.C.) for approval of funds. Then each item purchased during the program is separately approved before purchase by the government agency.

Schedules for production set the quantity require-

ment for new machinery. Man-hours required on each type of standard machine to meet planned production are usually pretty accurately known. In order to determine what new types of machines might be needed, one company's engineering department gives the plant engineering department an annual preview of new designs, so that needs for special machines can be anticipated. Others maintain a machine equipment group in the plant engineering department, which is constantly surveying the field for new methods and machines, with a view to their application to present or future production.

Keeping Records

In a mixed (partly Air Force and partly company-owned) facility, rental rates are usally established for space and equipment, then the total rent is divided between company and Air Force according to the ratio of commercial to Air Force contract direct hours. This allocation of charges is handled by the accounting department in the same way that they allocate overhead charges.

Location records on equipment are usually kept in the industrial or plant engineering department by number, location, and description (a three-card system). Location records on portable equipment are usually not kept current—are corrected only at inventory time. Miscellaneous equipment, such as stock bins and storage racks, are often lumped by department. Individual records on each such item are not kept.

Location records are required by the accountable property officer on Air Force equipment, and these records are used by the tax and insurance groups.

During a rearrangement, one company has trained the moving crew to correct the location records, another places that responsibility on the area layout man who initiates the rearrangement. All new equipment goes through the maintenance department for inspection, tagging, safety check, and the like, before assignment.

Machine Maintenance Problems

In regard to foreign machines, one company specifies that they all be equipped with domestic motors and electrical equipment as a condition to the purchase. The cost of changing foreign electrical equipment has been so high as to make the machines uneconomical unless purchased that way.

As far as preventive maintenance programs are concerned, some have no regularly scheduled program, but train their oilers to report incipient trouble. A preventive program is important where high-cost, high-precision equipment is involved. In one such plant maintenance people are sent to the factories of the machine tool builder for training in preventive maintenance. The preventive maintenance group in this plant is separate from the general maintenance group of the plant engineering department, and comes under the plant superintendent, where interest in preventing trouble is greatest. Special problems of maintenance are taken up directly with the machine tool builder, who sometimes has a factory maintenance crew available. Suggestions for improving the machine often develop.

The problem of reconciling training and selecting specialists who must work odd hours with union requirements for overtime distribution and the like can be resolved by setting up the special preventive maintenance department separate from the regular maintenance crew.

The man who will be doing the maintenance work is the person who is sent to the training school. Some factory schools are not as effective as factory-trained field service men for training the maintenance people, because the field service people are more familiar with the troubles that occur with their machines.

Some special machines have been sent to the factory for overhaul, but ordinarily this work is done either in the plant or by a local shop because of the problem of scheduling the overhaul time.

Based on inspection procedures set up when each machine is purchased, one company now estimates that a complete overhaul will add three years to the life of a machine. This company has set up a 15,000-sq-ft machine tool rebuilding shop, supplemented by outside contract shops, to handle its overhaul program. When it is estimated that the overhaul will add less than three more years to the life of the machine, it is replaced. Another company has a hand-down program for used machinery. When a machine cannot be made to hold the required tolerances it is transferred to an operation where the tolerances are not so great. This permits getting the maximum use from older machines.

Records tend to show that preventive maintenance is cheaper when down-time is considered as part of the cost. Regular inspection is the key to good preventive maintenance. If you wait until breakdown, the repair cost is usually much higher. Good preventive maintenance also involves the training of machine operators in good operating habits (avoid overloading, keep the machine clean, don't use high-pressure air for blowing chips, and the like). In one plant the machine operators clean the machines and charge their cleaning time to production (to the product). One hour per week is spent on a thorough cleaning of the machine, chargeable to the current production direct charge. Another has an eight-week training course for machine operators.

Getting production to release a machine for maintenance, that is, resolving the conflict between the man who has a production schedule to meet and the man who wants to repair the machine before it breaks down, is a continual problem—and a real one. Most solve it by negotation between the people concerned. One plant helped the problem by arranging for all except the maintenance people to take their vacations at the same time.

The part of the maintenance dollar that goes to preventive maintenance seems to vary widely. One estimated 10%, another 5%, and another 65%.

When a machine must be released for repair while it is still operating, the plant engineer arbitrates and sets a schedule for the out-of-service time at one plant. Another orders standby machines when schedules are tight, so that one may be immediately put in service to replace the one taken out for repair.

During the initiation of the repair program at one plant, acquisition of standby machines was approved by the Air Force. The Air Force requirement

that no equipment be idle is satisfied if all machines are either in use or being repaired. At another plant where all machinery is company-owned, deliberate plans are made for the purchase of standby units of critical machines.

When machines are scarce, the repair cost can be as high as 100% of new cost, but the machine will still be repaired because new machines are not available. Ordinarily, when the repair cost will be more than 30 to 40% of new cost, the plant engineer initiates paper to replace the machine, which moves the decision to the higher level (management or Air Force) required for approval of the purchase.

One manufacturer of precision equipment for electronic gear controls machine temperature by controlling the temperature of the coolant and by then circulating the coolant for an hour before using the machine. This plant has a rigid policy of cleanliness. The rule is, "Keep dirt out—don't clean it up." Electrostatic dust filters are used only in the master gaging and precision assembly areas, not in the machine shops. Plastic tile is used to eliminate the generation of dust from the concrete floors. "Duck-boards" are eliminated as dirt-catchers. Dirt control saves money by reducing wear; temperature control holds tolerances.

The practice of giving old, worn-out machinery to maintenance to use in repairing high-precision machinery probably does not exist as a policy, but it seems to be a tendency. Obsolete, but not worn-out machinery should be transferred to maintenance. It is admitted that maintenance sometimes gets a beating on machinery, which was one reason for setting up the separate preventive maintenance group under the plant superintendent at one plant.

Other Plant Engineering Problems

Most discussers agreed that requirements for better light, heating, and ventilating, refrigerated drinking fountains, and the like are increasing. All plants represented make an honest attempt to meet the demands, when they are reasonable. The importance of handling such problems uniformly through the plant was emphasized.

Most plants represented handle weekend maintenance on an overtime basis, with minimum coverage on a split-week basis.

Usually, requests for small items that require no scheduling into his work load can be accepted by the maintenance foreman. Larger jobs requiring either scheduling or an appreciable amount of new material are handled by written request only. Some plants distinguish between a maintenance repair and new construction, and require written request only for the latter. One requires written requests for all items, but routes these direct to maintenance when the cost is less than $50.

The report on which this article is based is available in full in multilithographed form together with reports of the nine other panel sessions of the 1952 SAE Aircraft Production Forum. This publication, SP-300, is available from the SAE Special Publications Department. Price: $2.00 to members, $4.00 to nonmembers.

Cockpit Standards . . .

. . . developed by Committee S-7 should be incorporated in new models of both commercial and military transports.

Excerpts from paper by **M. G. Beard,** American Airlines, Inc. (chairman of SAE Cockpit Standardization Committee S-7)

ALL new commercial and military transport models should be constructed with the cockpits conforming to the standards developed by S-7. All changes made to the cockpits of the models by operators after they have been put into service should conform to the standards.

Fortunately, it appears likely that the next round of commercial transport aircraft will be turbojet and turboprop powered. They will, in themselves, be fundamentally different from existing airplanes, so that pilots will, of necessity, be assigned specifically to such aircraft. Complete conformance of these cockpits with the new standards will, therefore, cause no difficulties in any airline system. The checkout time required on such planes should give pilots time to become fully accustomed to the new instrument panel arrangement if the airline had not previously converted the flight instrument panels on its piston-engine airplanes.

The main difficulty that may be encountered in new models powered with piston engines designed within the next 10 years is that these may naturally be integrated into the system along with the older piston-engine planes and if the airline has not yet standardized on the national standard flight panel, it will be faced with the decision of converting all existing flight panels at the time of introduction of the new model into operation or segregating the operation of the new model.

It seems quite clear that any movement to standardize flight instrument panels and controls on an industry-wide basis on existing transports would lead to great confusion and create unnecessary hazard during the transition period; it would also be very expensive and therefore should not be done except where interchange agreements between airlines make it necessary. At time of national emergency, the instrument flight panel and certain power controls should be standardized on the planes assigned to military airlift. These changes could be prepared for and parts stocked against the time of necessity. (Paper, "Cockpit Standardization—How Far, Now and in the Future?" was presented at the SAE National Aeronautic Meeting, New York City, April 24, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Gasoline Economy

Depends on the Driver, too!

H. S. White, O. Enoch, and A. L. Haynes, Ford Motor Co.

Based on paper "Gasoline Mileage—Good, Bad, or Indifferent" presented at SAE Metropolitan Section, New York City, Jan. 8, 1953. Complete copies of the paper in multilithographed form may be obtained from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.

ENGINEERS devote long hours to figuring ways to improve the gasoline mileage of vehicles. All their efforts can be pretty much lost, however, if the drivers of these carefully designed machines do not follow good driving practices and do not keep their cars in good running order.

Shown first—on the next page—is what happens to the mileage when a few of the many possible bad driving practices are indulged in. This is followed by a page that shows what happens when the car is not maintained properly in certain respects. Due to the large variations possible in major engine conditions, only small items of maintenance that are usually ignored are discussed.

The fuel distance meter shown below was used in the investigations.

The alternate filling and emptying of a bellows meters the fuel, while the turning fifth wheel measures the distance traveled.

The bellows movement is automatically controlled. The fuel pump pressure fills the chamber. The solenoid—actuated by an electric switch—closes the intake valve and opens the discharge valve. After 1.3 cc of fuel is used, another switch actuates a second solenoid, which reverses the operation.

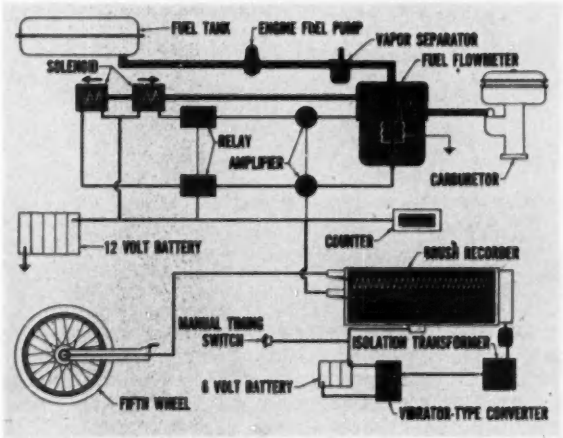
Each cycle of the flowmeter and each turn of the fifth wheel causes a pip on the recorder tape.

Shown below is what in effect is a summing up of the individual bad practices discussed on the next page. It compares mileage figures for good and bad (jackrabbit type, engine idling during long stops, and the like) drivers. It also shows how type of service affects the fuel economy.

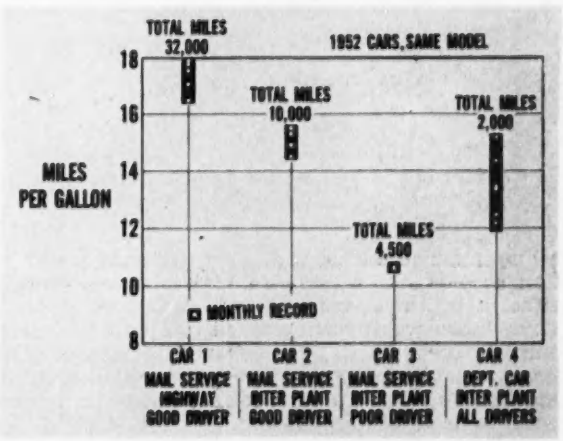
This chart is based on accurate fuel mileage records maintained over a considerable period of time for a number of vehicles, each operated under specific conditions. Four cars have been picked for this illustration, to show typical differences.

The fourth car was driven by several drivers to show the spread in mileage to be expected in such cases.

Instantaneous Fuel Consumption Meter



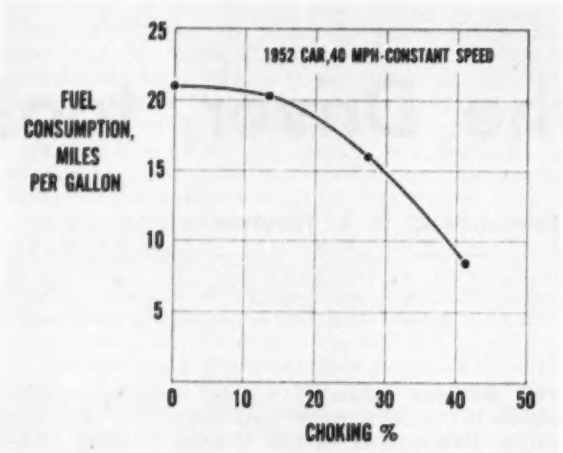
Effect of Driver Habits, Type of Service



PLEASE TURN PAGE

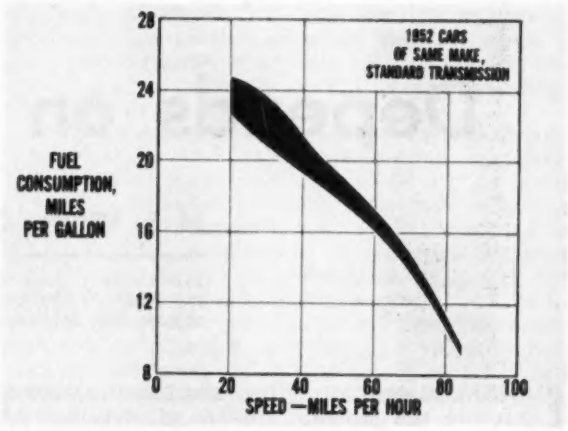
4 Good Driving Habits

Use Choke as Little as Possible



The contribution of the driver toward fuel economy—good, bad, or indifferent—starts when he pulls out the choke. It can be seen here that a small amount of choke doesn't affect mpg, but a large amount causes serious waste of fuel. It can also be seen that pulling the choke out more than 15% or about ¼ in. decreases fuel mileage rapidly at 40 mph. It is apparent that only the minimum required choke should be used, and the choke should be released as soon as possible.

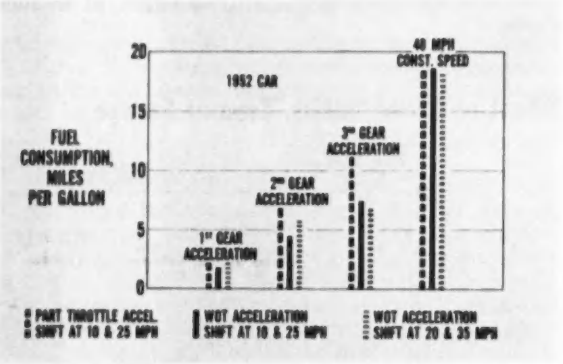
Keep Car Speed Down



Due to increased wind and tire losses, the driver who cruises at high speeds will get poorer gasoline mileage than the slower driver. Power required to overcome wind resistance increases with the third power of car speed. Although driving at 20 or 30 mph for the sake of economy is not practical, speed reduction from 60 to 50 mph, for instance, can increase economy about 12%.

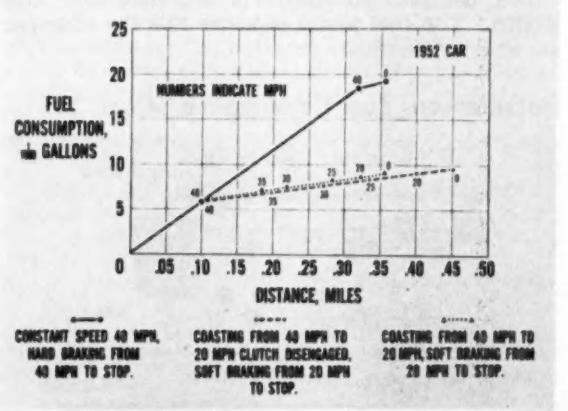
A good driver can still make time, however, for it is keeping a steady speed rather than driving at high speeds that results in a good average.

Accelerate in Third, If Possible



Fuel mileage during wide-open-throttle acceleration is shown to be best in high and not greatly affected by the speed at which gears are shifted. Thus, best economy is obtained by staying in high during acceleration. The chart also shows that least fuel is used when the gas pedal is used so cautiously that the power jet does not operate during part or all of acceleration. Savings depends, of course, upon the effect of the power jet on economy, which varies with the carburetor.

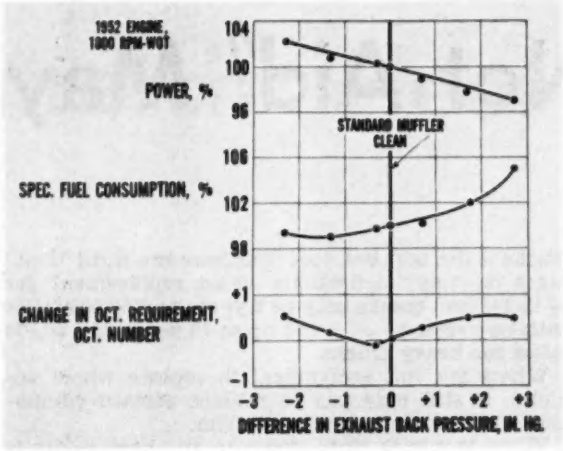
Slow Down Slowly



It may be seen that the driver who held his gas pedal down continued to use fuel at the 40-mph rate while the other two used it at idle rate. The engine ceases to propel the car, but kinetic energy brings it over a considerable distance during coasting. The jackrabbit driver converts this energy to brake lining and tire abrasion. The result is 100% increase in fuel consumption.

4 Good Maintenance Habits

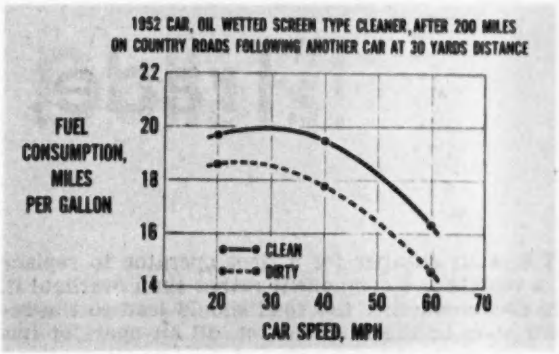
Keep Muffler Clean



Proper maintenance of all units of an engine will result in maximum economy.

For instance, a plugged muffler or pinched tail pipe may cause both power and economy losses, as shown above. Naturally, wide-open throttle suffers more than part load. The engine likes free inhaling, but it also objects to restricted exhaling. The above graph shows a 1% power loss per 1 in. hg exhaust back pressure. It also shows the effect of back pressure or restriction on octane requirement and fuel economy.

Keep Air Cleaner Clean



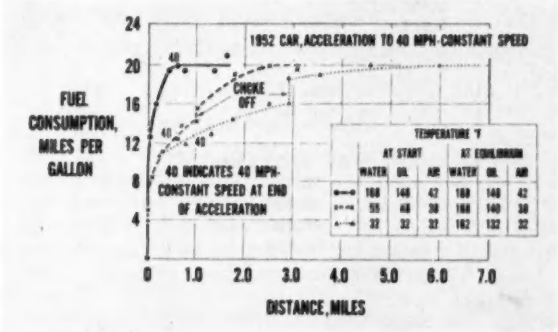
The effect of a dirty air cleaner on fuel consumption is shown by the above graph.

As may be noted by the curves, the dirty air cleaner resulted in a fuel consumption about 1.5 mpg higher than when the engine had a clean air cleaner, over the 20- to 60-mph operating range.

It should be realized that this is a rather extreme case, for the dirty air cleaner contained about 200 grams of dust.

Actually, this amount of dust was accumulated on the test bench equivalent to 200 miles of gravel country road driving 30 yards behind another car.

Keep Car Garaged in Cold Weather



The same car was started when the air was 32 F; when the air was 38 F, but the engine was somewhat warmer, simulating garage protection; and when the air was 42 F, but the engine was well heated up. In each case, the car was started, choked as far as needed, shifted through gears, and then driven at 40 mph until warmup was completed. About seven times the distance was needed to warm the engine sufficiently to give 20 mpg after the "cold" start as after the "hot" start. The garage-kept car gave results in between the extremes.

Keep Tires Properly Inflated

(7.10 x 15-4 PLY BALLOON TIRES
CAR WEIGHT: 3960# CAR SPEED: 30 MPH)

INFLATION PSI	POWER ABSORPTION (4 TIRES) B.H.P.
20	7.60
24*	6.64*
28	5.76

*STANDARD

Courtesy of Firestone Tire & Rubber Co.

Tire pressure is also a factor of fuel economy. With tire friction absorbing approximately 15% of the engine power, it seems worth while carefully to select and maintain the optimum tire inflation pressure. The data shown in the above table represent 4-ply balloon tires for medium-size cars. The table shows that power absorption increases greatly as tire pressure drops. At 30 mph and normal car load, power absorption by the tires changes about 15% for a 4-psi change in inflation. Pressure has to be low in order to deal with rough road surfaces, but not too low in order to keep tire friction and car road stability at a reasonable level.

"Trade, Not Aid" May

IT'S often cheaper for a fleet operator to replace a vehicle or a component rather than overhaul it. To decide whether the road should lead to the repair shop or the used car lot, all an operator has to do is study the economics of the two alternatives.

When this is done, it generally turns out that fast replacement (before an overhaul) pays off with fleet vehicles of the high-volume, mass-produced, light types. For example, fleet sedans can often be replaced at one year or 20,000 miles with substantial overall savings.

Sometimes fast replacement of light and heavy trucks is the best bet, too. But here the word "fast" takes on many definitions. Fast replacement for ½ to 1½-ton trucks may be 5 years and 50,000 miles with no overhaul . . . and up to 10 years and 50,000 miles for heavy trucks.

Where it's not economical to replace whole vehicles, it still may pay to replace certain components rather than overhaul them.

When it comes right down to it, there really is no stock answer to the question: Replace or repair? That's because fleet conditions, current costs, cost trends, and many other important factors vary—

Table 1—Savings Possible with Fast Replacement of Sedans

Operation	Sell at 20,000		Sell at 60,000	
Fuel	19.7 mpg	1.52¢	15.8 mpg	1.90¢
Oil	800 mpq	0.04	450 mpq	0.07
Miscellaneous services (antifreeze, wash, tire chains, and so forth)		0.60		0.60
Tires (includes damage and repairs)	Replace ½ set	0.05	Replace 2½ sets	0.31
Storage[a]		0.40		0.50
Total		2.61¢		3.38¢
Maintenance				
Lube jobs	10 at $1.50	$15	30 at $1.50	$45
Gear oil changes		15	5 at $2	10
Initial service[b]				50
Preventive maintenance service	1 at $45	45	At 10,000 miles	45
			20,000	75
			30,000	50
			40,000	90
			50,000	50
Miscellaneous repairs (between preventive maintenance)		15		60
Seat cover replacement		$90		12
Total				$487
Per mile		0.045¢		.081¢
Depreciation				
Purchase cost		$1500		$1500
Sales price		1250		500
Actual		250		1000
Per mile		1.25¢		1.66¢
Total cost		3.90¢		5.12¢

[a] Little outside storage for fast replacement.
[b] Seat covers, underbody spray, adjustments, marking, oil filters, and so forth.

Stretch Fleet Dollars!

C. C. Hudson, Tennessee Valley Authority

Based on paper "Fast Replacement or Heavy Maintenance" presented at SAE Annual Meeting, Detroit, Jan. 12, 1953. This paper will be published in full in 1953 SAE Transactions.

and all play a part in determining whether it should be fast replacement or heavy maintenance. It is possible, however, to set up a simple arithmetic formula that, when used, will tell whether vehicle replacement is justified economically. Before taking a look at such a formula—and how it is used—it might be well to review:

- The case for fast replacement.
- How fast replacement can pay off.
- What holds back advocates of fast replacement.
- What overhauling offers.
- What's needed to make fast replacement of component parts more desirable.
- When heavy maintenance . . . fast replacement.

Case for Fast Replacement

In 1932 with 35¢-per-hr mechanics on a 50 hr week, it was possible to reclaim, salvage, and rebuild parts economically. Parts then cost more than labor. But they don't now! With job shop labor costs running $3 to $4 per hr, we are in an age calling for less maintenance and faster replacement.

Of course, mass production factory costs are up too, but there volume permits small savings that help offset rising basic costs. Admittedly, much can be done to increase efficiency in job shops, but this will take time.

Meanwhile the case for fast replacement can be improved even more. Right now, for example, it takes 1.2 hr (flat rate) to overhaul a small carburetor but only 3 hr to build it; 1.3 hr to overhaul a distributor, but only 2 hr to build it. It's true that prices operators pay indicate more hours for production, but don't forget they include heavy profits to middlemen. The thought then arises: What service do all these middlemen render to a fleet? In short, wouldn't it be possible to simplify part distribution systems and reduce costs to at least the larger fleets? Needless to say, this would permit operators to replace more assemblies when trouble occurs.

Even as things stand now, however, fast replacement of both vehicles and components reduces fleet investment in shop equipment and space.

How Fast Replacement Can Pay Off

Most rental companies in this country replace passenger vehicles annually or at about 25,000 miles. Of course, appearance and new models have sales appeal. But economic justification for fast replacement does not rest solely upon sales appeal.

Retirement of a sedan at approximately 20,000 to 25,000 miles means that maintenance is principally grease jobs and accident damage. There are no overhauls, no engine, valve, and clutch jobs, and no new spark plugs and tires in many cases. Maintenance cost of ½¢ or less per mile, and excellent operating cost (fuel and oil consumption is low for new vehicles) go hand in hand with fast replacement.

Table 1 illustrates savings possible with fast replacement. It shows a cost estimate for light 4-door sedans on the basis of replacement after 20,000 miles (1.5 yr) and after 60,000 miles (4.5 yr). Note that 1.22¢ per mile savings are possible with fast replacement!

Planned retirement and replacement of vehicles pays off in other ways too. It permits maintenance to be tailored to fit service life—and this is mandatory for lowest costs *whether replacement is fast or slow.* Unless the approximate time of replacement is known, unnecessary repair work will be done.

But replacement plans need to be adjusted from time to time to fit current conditions. Good fleet

management reviews and studies cost data and cost trends . . . and revises the replacement plan item by item as neeedd.

What Holds Back Fast Replacement

Some fleet superintendents who strongly favor fast replacement have to follow a relatively slow replacement schedule. That's because of:

1. Failure to sell the idea to all levels of management.

2. Unavailability of funds.

3. Effect on current and future taxes—although with a constant upward trend, the tax effect should favor fast replacement.

4. Long period adherence to agreed-upon service lives—occasionally book values which have no reference to current overall costs.

What Overhauling Offers

Next it might be best to consider what benefits can accrue from overhauls. Information gathered on this from fleets totaling 46,000 vehicles (36,000 in the United Kingdom and 10,000 in the U. S.) is shown in Table 2.

If these data are correct, fleet shop overhauls are amazingly good and cheap. But at the risk of provoking an argument with the people who furnished this information, *I question it.* Do we really get 83% restored reliability and 70% restored life for a cost of 26% (of new vehicle cost)? If we do, why do we ever replace? Appearance and technical advances aren't worth 74%.

The nearest to full life restoration that TVA ever got came with a group of war-surplus Diamond T Model 981 tank-retriever 6×4 trucks. These were low-mileage vehicles returned from overseas. We replaced the Hercules 895 cu in. diesel engines with Hall-Scott 1040 cu in. engines; replaced Fuller 3-A-86 auxiliaries with Spicer 703 and 8031 top power take-off jobs; changed exhaust systems; air-cooled the cabs; replaced the prime mover body; installed power-boost steering; and reworked other components. The total cost, including 45% overhead applied to labor, was $8000 to $15,000—with an average of $13,000. And for this we got 90% service life and 90% reliability as compared to a comparable $16,500 new truck.

As a further example of what TVA is able to get, our 24,000 to 35,000-lb gvw trucks costing $8000 sometimes are given $3000 to $4000 overhauls. For this 40 to 50% of replacement cost, we get a life restoration of 75% and reliability of 75 to 80%.

Naturally it pays to recheck total overall costs, actual life from such overhauls, and failures or troubles after overhauls.

How To Make Fast Replacement More Desirable

It may be concluded, then, that fleet operators do not get all they should from overhauls—even with heavy vehicles where overhauls are justified economically. More "fast" replacement with new or factory-rebuilt units is indicated. To make this economically feasible, operators need:

1. Lower first cost of components—to encourage fast replacement.

2. More direct parts distribution at lower prices—low enough to permit removing and throwing away even semi-major components.

3. More component standardization—to encourage regional rebuilders.

4. Vehicles designed so that all components wear out together.

Fleet operators have discussed the idea of same-life parts for several years. While we want long-life vehicles, we might be willing to sacrifice a little life for machines in which all parts wear out together.

Every fleet has data showing that radiator and clutch life are less than engine life. Transmissions last about as long as engines, but it's often necessary to open or remove them to repair one bearing, synchronizer, or gear. And it's these in-between failures that are the expensive ones!

Why shouldn't the radiator bolted to the engine be as trouble-free as the cylinder head? Why shouldn't we expect batteries to last as long as engine valves without frequent service? Why shouldn't we expect distributor points and spark plugs to last until the first ring job? Why should we have 40,000-mile valves in an 80,000-mile engine? We could go on and on citing such examples, but these will serve to illustrate why balanced component life is needed so much.

When Fast Replacement?

Few fleets today can afford to pass up the savings inherent in annual or 20,000 mile replacement of sedans. Fleet discounts will not eliminate actual depreciation for one year, but with good buying they should make real depreciation very low.

Fast component replacement can offer savings, too, with a little encouragement from industry.

Trucks, on the other hand, present special problems of their own—for each class, for each fleet, and almost for each year. Fast replacement may vary from 5 yr and 50,000 miles with no overhaul for ½ to 1½-ton classes . . . to 10 yr and 50,000 miles for heavy trucks.

But whether sedans, trucks, or individual components, fast replacement must be justified on a total cost basis. And all engineers like to apply a formula to problems. The one offered here is a simple arithmetic one. Perhaps it is too simple to call a formula.

$$\text{When } \frac{a+b+f-c}{x} > \frac{a+e-d-w}{y} = \text{Sell}$$

Where:

a = Original cost of vehicle under consideration for disposal

b = Cost of repairs required to continue it in service

c = Salvage value of old vehicle at end of extended service life (after repairs covered by b)

d = New vehicle salvage value at end of normal life

e = New vehicle cost (current)

f = Difference in operation and maintenance cost of old and new vehicles for extended life (after repairs)

x = Total life of old vehicle—life to date, plus extended life due to repairs

y = Total life of old vehicle (if sold now), plus ex-

pected life of new vehicle (life to date of old, plus normal life of new)
w = Current sales price or value of old vehicle

Note:

1. Life should be expressed in miles or hours although age can be used.
2. In some cases, there may be no difference in operation and maintenance cost between the old vehicle after repair and the new vehicle. But it is normal to expect some difference. Repair or overhaul rarely restores complete efficiency. Also newer vehicles usually have some improvements which offer lower operation and maintenance costs.

This formula came into existence because vehicle replacement in TVA has been on an economic justification basis for many years. Let's substitute the following typical figures for the letters in the formula and see what we get.

a = $2289
b = 900 To extend life 46,000 miles
c = 250 At 80,000 miles (Current 34,000 plus extended 46,000)
d = 200
e = 1934
f = 230 (½¢ a mile for 46,000 miles)
x = 80,000 miles
y = 114,000 miles
w = $400

When $\frac{2289 + 900 + 230 - 250}{80{,}000} > \frac{2289 + 1934 - 200 - 400}{114{,}000}$ = Sell

When $\frac{3169}{80{,}000} > \frac{3623}{114{,}000}$ = Sell

$\$0.0396 > \$0.0318$ = Sell

Using such a formula to determine economic justification for fast replacement has advantages and disadvantages. The advantages are:

1. Easy for even low level supervisors to use.

2. Forces individual considerations into an overall policy based on averages useful for planning operations.

Table 2—Fleet Operator Opinions on What Overhauls Offer

Fleet	Overhauls: Restore Reliability, %	Overhauls: Cost in Per Cent of Replacement Cost	Overhauls: Life Restoration, %
1	100	10	—
2	90	16	—
3	93	50	—
4	75	25	—
5	75	20	—
6	60	25	50
7	90	40	90
Average	83 (75-100)	26 (10-50)	70 (30-50)

3. Includes as major factors—real depreciation, current sales prices, replacement vehicle cost, and service life restoration.

4. Gets very close to the true cost—the great American measurement understood by all—the dollar sign.

Disadvantages outnumber, but not necessarily outweigh, the advantages. They are:

1. Good estimates are mandatory.

2. Appearance for advertising and driver pride is not included.

3. Past expenses are included—some authorities oppose using original cost and utilization to date.

4. Poor purchasing in the past can force holding a vehicle longer. (Is this bad? Shouldn't purchasing mistakes be emphasized to this extent?)

5. Extra capacity (or useful work) of new vehicles is not considered.

6. Lost time of vehicles is not covered.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Based on Discussion

E. B. Ogden,

Consolidated Freightways, Inc.

THE bulk of our fleet is composed of over-the-road heavy-duty trucks and trailers in the $25,000 class . . . and these vehicles do not lend themselves to fast replacement. It's considerably more difficult to trade-in this type of equipment.

As for sedans, they present no problem since we have relatively few of them. However, our policy is to replace them at 60,000 miles (two or three years). And this has proved very satisfactory. Replacement is made before the first overhaul.

The author points out that parts are cheaper than labor today. This may be true of parts for vehicles in lower price classes, but it certainly is not true of many parts for over-the-road vehicles. For example, a new worm shaft costs $148, while the cost of reconditioning one runs from $10 to $15 . . .

a new brake cam costs $11.10; reconditioning costs $2.50 to $3.

I agree, however, that a fleet superintendent must constantly review the practice used in his shop in regard to what is economical to salvage. He must check this by reviewing actual average cost, and not just rely on what the shop man tells him he thinks it costs.

The author seems to question that we receive 83% restored reliability and 70% restored life for 26% of new cost. I do not think this is out of reason. In fact, I don't consider the Diamond T Model 981, cited as an example, an overhaul at all. It could more accurately be called a redesign, using the frame and wheels as an excuse to start. For that matter, if such practices were carried out in general, there would never need to be any replacement of equipment. All advancements in design would be incorporated during overhaul or rebuilding.

Our practice is to keep the vehicle as near to factory standard as possible for the entire time it remains in the fleet—be it 6 or 12 yr. In this way, heavy expenditures, such as outlined for the Diamond T, do not occur.

Referring to the example of the 24,000 to 35,000-lb gvw trucks, it would seem that some redesign must have been worked in to come out with a $4000 overhaul on an $8000 truck.

Some years ago we followed, to a large degree, the practice of trying to incorporate the latest developments into each old vehicle when it was overhauled. In so doing, we found that our costs resembled those on the Diamond T.

We feel the practice is unsound. Therefore, there comes a time when replacement is necessary and desirable from the maintenance standpoint, leaving all other factors such as taxes, book values, and so forth, out of the picture entirely.

As for lower prices and direct distribution of replacement parts, I feel that the replacement part pricing system is downright shameful. There are at least two profits in every part for which there is no justification. When it is possible for large fleets to secure 60% discounts after going through channels, imagine what savings could be made in fleet maintenance if even two of these profits didn't exist.

Most of us know that many original units are sold at a very low profit margin to get them in service so as to enjoy the parts business. This whole practice needs revision.

More component standardization from the standpoint of fleet shop maintenance is most desirable, whether or not it encourages regional rebuilders. However, I don't hope for too far-reaching an improvement, since sale of vehicles is largely dependent on so-called outstanding improvements in new models. And this, in turn, usually results in changes in so-called standards.

The Utopian condition of having all parts wear out together is the end toward which we have been working for years. However, I do not think we have ever suggested that any part should purposely be made with less life so as to balance it with some other part of the unit. Rather we have been harassing manufacturers to increase lives of offending parts. I fear that if we use any other approach we might, in the end, wind up with an inferior product with about the same price tag on it. No, let's not lower the bars to admit an inferior product—rather let's find better material and better design to improve the short-life parts.

T. L. Preble,

Tide Water Associated Oil Co.

THIS paper should induce fleet operators and their bosses to re-examine overall motor transportation cost data and formulas for vehicle retirement (if they have one). It should prompt them to re-evaluate each element in their formulas, and try again to eliminate as much of the empirical as possible.

Vehicle retirement deserves intensive study. It is a difficult problem, loaded with variables, which I doubt will ever be solved completely either by educated guess or by mathematics. The operator must use his soundest judgment in retirement studies, keeping overall economy in mind. The somewhat vague term "overall economy" refers here to: (a) operating expense, (b) investment account, and (c) to a constant realization that both (a) and (b) are cash out of the corporate till.

This paper contains "take home pay" for many of us who are interested in transportation and maintenance, and it should be of more than casual interest to our vehicle-designing colleagues. But I think the latter may, with this discusser, raise a skeptical eyebrow over the author's expressed hope for vehicles with parts that will all wear out together.

D. K. Wilson

Niagara-Mohawk Power Corp.

WE fully agree that, divorced from comparisons with other types of equipment, fast replacement of mass-produced, light vehicles is sound.

However, in a mixed fleet, ranging from mass-produced, light vehicles to highly specialized jobs, the problem becomes more complex. Retirement formulas, applied without regard for other than light vehicles, tend to limit one's thinking to a like-for-like replacement. Often overlooked, therefore, are possible applications of new developments, methods, and work techniques.

E. P. Gohn,

Atlantic Refining Co.

THE author's paper ought to wake us up to some economic facts. We don't get the same changes in fuel and tire costs with mileage as shown in Table 1, but we do get about the same total costs. If we run a vehicle 20,000 miles, we get the cost per mile down just about as low as if we run it 60,000 miles. So why not sell at 20,000 miles?

Aim of Production Control

Roy L. Anderson,
Douglas Aircraft Co., Long Beach

Report of Panel on Production Control held as part of the Aircraft Production Forum at the SAE National Aeronautic Meeting, Los Angeles, Oct. 1, 1952. Panel leader was J. B. Adams, Industrial Plastics, Inc., and panel coleader was F. W. Lloyd, Northrop Aircraft, Inc.

PRODUCTION men in the aircraft business still are searching for answers on manufacturing controls. They want better ways of planning shop functions and devices for keeping tabs on them, also ways of anticipating troubles before they do any damage.

For example, the open versus closed stockroom is going strong as an unsettled controversy. (In an open stockroom, parts are accessible to production people, with checking in and out of parts done by production people, indirect labor, or a combination of both. A closed stockroom is a controlled stockroom maintained by indirect personnel. Parts are checked in and issued to the production line as required.)

There may be some misuse of parts in an open stockroom. It's generally conceded that parts losses are high at first when switching from controlled to open stockrooms. It drops back to a normal minimum level after a short period. In one case there was evidence of even lower losses than with controlled stockrooms.

Reports of shortages in an open stockroom system come from various sources. In some cases production people report shortages to line supervision, who in turn check with production control; together they coordinate the follow-up activities. In other instances, production control or indirect personnel report the shortages. Neither line production nor production control can handle the shortage problem independently. It takes considerable coordination to get a workable system.

In a controlled stockroom, operations include ordering, dispatching, issuing, and inventorying all materials, parts, and equipment. Costs are determined when parts are received in the stockroom.

Parts are issued by requisition to the next assembly number. When that assembly is complete, the cost is available for that phase. This is repeated until a finished product is produced. Periodic audits are made, with overages and shortages held to a minimum at the end of the contract.

An open stockroom may be more alert to shortages than a closed one. That's because production people, by long association, recognize the parts with which they work. In a controlled stockroom containing thousands of different parts, this kind of recognition is not so likely.

What Type Stockroom

Lot size in manufacturing as well as airplane or product size may determine the type of stockroom or combination that's most suitable. Large, complex formed sheet metal parts or skins that scratch easily may require close control. Individual plant pratcices as to accountability of parts may dictate stockroom policies. That's particularly so where a contract shifts from "cost plus fixed fee" to "fixed price."

With few exceptions, no one system seems to be used to the exclusion of the other. Combinations of both generally are used.

Decision as to whether the stockrooms should be centralized or decentralized hinges on at least four factors:

1. How close are the buildings to each other?
2. What's the break-even point in transportation?
3. How valuable are the parts? High cost or easily damaged items may call for

close check and careful issuance. Low-cost items, such as standard or free list parts, may be issued directly to the line at various points.

4. Is it a multiplant operation (two or more plants within close geographical limits)? Considered here is the organizational setup, the amount of work done in the various plants, material purchasing, fabrication arrangement, and so forth.

There is some variance too in methods used for controlling auxiliary items and common parts. In one plant, if the same part is used at several points along the assembly line, it is fabricated on one order. The parts are routed to a central dispatch point, checked there by a linedex system for use points, and then routed to these points. Shortage forecasting and parts follow-up are handled from the central dispatch station.

Production control men also are giving serious attention to damage control in materials handling. One manufacturer has a committee of representatives from various phases of the plant organization. It analyzes damage to parts and is empowered to ask for changes in material handling or processing. This group also spots the damage source so that corrective measures can be applied.

There are preventive approaches too. Shop or work orders can be written with instructions to workers on precautions or procedures for handling materials.

Work Flow Load

All aircraft plants use shop loading schedules in one form or another. The systems vary as well as the units used for expressing shop load—such as machine hours, manhours, dollars. But no one plant feels it has the key to the problem. Here are the ways some of them are handling shop loading:

- Company A—Each order is loaded individually according to the setup and run time. Start and completion dates also are indicated on each order. This is considered a most complete, although complex system.

- Company B—First release is scheduled on a requirement basis, without regard to peaks and valleys that may result. With data obtained from this first release, the second and subsequent releases are scheduled to level the shop load. Capacity of individual machines, or groups of them, is figured at 70%—with a 30% contingency for reruns of rejections, shortages, lost parts, and so forth. Shop load is extended from this data into the future to indicate what areas may be critical as to capacity of machines or manpower needs. Labor loads are made for a machine group against a capacity line. Orders are adjusted if peaks or valleys in the future are indicated. Both requirement date and shop load date are shown on shop orders.

- Company C—Total manpower requirements are determined by department—such as punch press, drop hammer, metal fittings, and tubings. Release of orders to manufacturing is made early enough to permit internal adjusting to level loads.

- Company D—Orders are scheduled to line requirement basis for first release. Subsequent orders are levelled on an order basis. Orders are released from production planning to a central release file. Before actual release for fabrication, estimates are tabulated by machine groups for short range forecasting. If peaks or valleys are indicated, work is either diverted to outside sources or shifted internally. Long range forecasting is done by labor loads furnished to each fabricating department.

When to schedule is one problem. But how large a lot to produce or the cycle of repeat fabrication release are equally important considerations. Production control men agree that cycling of repeat releases depends on two things: (1) rate of production, and (2) ratio of setup of time to run time. Most feel the cycle should run 45 to 60 days. This allows normal time for return of tools, for rework of damaged tools, or changes due to engineering or production.

Time spans allowed each manufacturing department vary from company to company, but the following seems to be a generally used pattern: (a) parts fabrication . . . two to four weeks; (b) subassemblies . . . one day to two weeks; (c) major assemblies . . . net to installation; and (d) line supply . . . two to 6 weeks.

(The report on which this article is based is available in full in multilithographed form together with reports of the nine other panel sessions of the 1952 SAE Aircraft Production Forum. This publication, SP-300, is available from the SAE Special Publications Department. Price: $2.00 to members; $4.00 to nonmembers.)

These specialists on keeping tabs on production dished up answers on current production control headaches in the aircraft business. They are, left to right: Secretary Roy L. Anderson, Douglas; P. J. Prescott, North American; Panel Coleader F. W. Lloyd, Northrop; Panel Leader J. B. Adams, Industrial Plastics; M. A. Garrett, Douglas; C. W. Seymour, Jr., Solar Aircraft; and C. W. Waston, Boeing

Problems with Hydraulic Systems for Tomorrow's Planes

PART I – EXTREME TEMPERATURES

TOMORROW'S airplanes impose two hard-to-meet requirements on hydraulic systems:

They must withstand a wide range of temperatures.

They must perform their many jobs reliably. (Part II of this article in next month's Journal will go into ways to achieve reliability.)

Components of future hydraulic systems will encounter temperatures of 400 F and maybe higher. The heat will come from the friction of air passing over the airplane skin at high speed and from nearby turbine engine hot parts. In low-drag, compact aircraft, designers can't help but put hydraulic lines close to engines and other heat-generating units.

High-energy hydraulic systems even develop considerable heat within themselves. And to add to the heat troubles, the air at the high altitudes at which tomorrow's planes will be flying is too thin to carry away much of the heat.

Besides high temperatures, airplane hydraulic systems face low temperatures on the ground in Arctic regions. Portions of hydraulic systems may be exposed to very low temperatures in high-altitude flight also. Experts agree that hydraulic systems must be designed to operate down at least to – 65 F, and some say as low as – 100 F.

Presently used fluids compounded for - 65 to 180 F operation will definitely be inadequate for future aircraft. Their viscosity is too low at temperatures above 180 F.

Chemists are looking for new types of hydraulic fluid that will be stable up to 400 or 450 F and still have good oxidation resistance and low vapor pressure. The fluid should be non-corrosive to steel, titanium, aluminum, and possibly other metals; be non-toxic; exhibit a viscosity of at least 3.5 centistokes at 400 F and preferably at 450 F and no more than 2500 centistokes at - 65 F; not hydrolyze; resist shear; have a pour point below - 65 F and a flash point above 400 F; and be non-foaming. And don't forget, the fluid must lubricate sliding and rolling steel on steel surfaces.

The chemists haven't yet found a fluid that qualifies. But they have high hopes for organo-phosphorus compounds, carboxylates, and organo-silicon compounds.

Once we have the ideal fluid, the problem will be to provide seals and mechanical components like valves, pumps, and actuators that are compatible with the fluid. Just as important, they must be able to stand the heat themselves.

Facts on progress on fluids, sealing compounds, and components follow on the next 5 pages

Fluids

J. C. Mosteller and Lt. J. A. King

The U. S. Air Force research and development laboratories have investigated extensively as hydraulic fluids organo phosphorus compounds, the carboxylates (or, as they are commonly called, the esters), and the organo-silicon compounds. The base materials for high-temperature hydraulic fluids were selected on stability to oxidation and corrosion, viscosity, low volatility at elevated temperatures, and anti-wear properties.

Organo-Phosphorous Compounds — These have been investigated as potential high-temperature hydraulic fluids chiefly because they have reduced flammability. Desirable properties such as lubricity and low temperature coefficients of viscosity can be found in selected compounds. Base materials were prepared from the alkyl and aryl phosphates and phosphonates.

The alkyl phosphonates were the only members of this class of compounds which had the desirable viscosity properties and extended liquid range necessary for a high-temperature hydraulic fluid. The phosphonates were evaluated in a high-temperature oxidation and corrosion test at 347 F and were found to be corrosive. All known oxidation and hydrolysis inhibitors were tried in these materials and none functioned satisfactorily. A fluid was formulated for comparative purposes using bis (butyl) isooctane phosphate and a conventional polymethacrylate viscosity index improver. The viscosity properties of the fluid are:

Temperature, F	Viscosity, cs
-65	2333
-40	544
100	13.8
210	4.55
400	1.75 Extrapolated

Although the present studies in organo phosphorus compounds have failed to produce a desirable high-temperature hydraulic fluid, further consideration should be given to these compounds when more effective inhibitors or more stable materials become available.

Carboxylates or Esters—These have been extensively investigated under USAF contracts as fluids and lubricants. Only the diesters proved worth considering; monoesters that had suitable viscosity properties for high-temperature hydraulic fluids had low flash points and exceptionally high vapor pressures at 400 F.

Carboxylates of the diester class are considered to be promising for high-temperature hydraulic fluid applications since these materials possess good stability and lubricating properties, have a wide liquid range, and low vapor pressures at 400 F. The

Table 1—Properties of Diester-Base High-Temperature Fluids

Properties	Diester Fluid A	Diester Fluid B	Diester Fluid C
Viscosity, centistokes, at			
210 F	4.51	4.95	5.3
130 F	10.1	11.1	
100 F	15.4	16.9	20.8
0 F	179	193	374
-40 F	1150	1220	2700
-65 F	6300	6070	16,000
ASTM Slope for 210 F to -65 F	0.62	0.60	0.60 (210/100 F)
Flash Point, F	415	360	450
Pour Point, F	-75	-75	-75
Oxidation corrosion	Satisfactory	Satisfactory	Satisfactory
Hydrolytic Stability	Satisfactory	Satisfactory	Satisfactory
Wear characteristics as Measured by Shell Four Ball Wear Tester at 800 rpm for 1 hr			
1 kg	0.16	0.21	0.13
10 kg	0.28	0.62	—
40 kg	0.78	0.91	0.40

This is the first of a two-part series. This part is based on the papers:

Limitations of Synthetic Rubber Packings for High-Temperature Applications

by E. L. Carlotta and E. M. Hobein
Parker Appliance Co.

Adventures in Extreme Temperature Hydraulics

—by George Keller
North American Aviation, Inc.

The Development of High-Temperature Hydraulic Fluid

by Lt. J. A. King and J. C. Mosteller
Wright Air Development Center

High-Temperature Problems Associated with Aircraft Hydraulic Systems

—by F. C. Mittell
North American Aviation, Inc.

These papers were presented at a symposium on High-Temperature Hydraulic Systems at the SAE National Aeronautic Meeting, New York, April 22, 1953. The complete papers are available in multilithographed form from SAE Special Publications Department at 25¢ each paper to SAE members and 50¢ to nonmembers.

viscosities at - 65 F of the more conventional diesters range from 1000 for bis (3-methylbutyl) adipate to 7600 centistokes for bis (2-ethylhexyl) sebacate.

In the formulations of diesters for high-temperature use, polymethacrylates have been used as viscosity index improvers. Recent investigation has shown that polysiloxanes may also be used as thickeners, and fluids prepared from these compounds will have lower - 65 F viscosities than fluids prepared with polymethacrylate thickeners. Test data are incomplete on diester polysiloxanes fluids.

Three diester fluids suitable for high-temperature hydraulic fluid applications have been formulated using polymethacrylate viscosity index improvers and organo-phosphate anti-wear agents. The physical properties of these fluids are listed in Table 1. Fluid A and C have been extensively service tested in lubricant applications. Fluid A contains an ester of a secondary alcohol and is therefore less thermally stable than Fluids B and C. Fluid C was originally formulated as a gear and engine lubricant. Because of its excellent properties this material should be given consideration as a potential high-temperature hydraulic fluid where - 65 F viscosity requirements permit a material of this high viscosity to be used.

Ortho Silicates—These are considered to be the most promising materials for the formulation of a high-temperature hydraulic fluid which will operate from - 65 F and also have low vapor pressures at 400 F. These compounds can be made hydrolytically stable by fabricating a steric-hindered molecule and adding a stabilizer. In this program a great variety of these compounds were synthesized and evaluated for oxidation corrosion resistance, hydrolytic stability, and lubricity. Silicate compounds of the proper configuration when stabilized were evaluated in the high-temperature oxidation corrosion test at 347 F. These materials displayed stability equal to that of the diesters.

Extensive formulation studies were conducted utilizing stabilized alkyl silicates and adding polymeric thickening agents to obtain the proper viscosities. The polysiloxanes and the polymethacrylates both functioned satisfactorily as viscosity index improvers, but the polysiloxane-thickened fluid had superior viscosities.

Although the silicates had good viscosity properties and stability, as hydraulic fluids they must adequately lubricate the pump and components. When the wear properties of the orthosilicates were measured on the Shell Four Ball Wear Tester it was found that these materials had lubricity comparable to that of a light mineral oil.

Three finished high-temperature hydraulic fluids have been formulated utilizing alkyl silicates and adding polysiloxanes as viscosity index improvers.

One silicate-base fluid having a viscosity of 2504 centistokes at - 65 F and 3.3 centistokes at 400 F was considered to most nearly meet the requirements for a high temperature hydraulic fluid which will operate from - 65 F to 400 F. This fluid is being evaluated by the U. S. Air Force and hydraulic system component manufacturers. A fluid improvement program will be guided by these evaluations to insure that this material will be a good high-temperature hydraulic fluid.

Please turn page

Rubber Packings

E. L. Carlotta and E. M. Hobein

The silicones at this time offer the most satisfactory answer to dry heat-resistant rubber requirements. They seem to have at least a slight edge over the polyacrylics and the lactoprenes.

Silicone rubbers are valuable for these four basic properties:

1. Resistance to Temperature Extremes—Temperatures as high as 525 F have little effect on the physical and electrical properties of silicone rubber—an outstanding property and an important factor in many applications. Low compression set at high temperatures plus high thermal conductivity are also important properties to be considered.

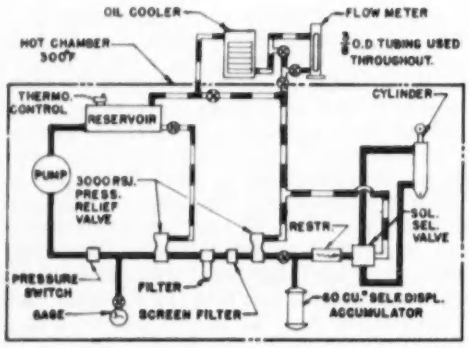
2. Release from Sticking—Silicones release readily from sticky materials over a wide

How Far Can We Go With Present Components?

Frank C. Mittell

NOW that increased temperatures are a definite problem, it has been found that many hydraulic system components will operate satisfactorily at 200 F and, with modifications, up to the 250–300 F range for relatively short periods.

A simple hydraulic system, shown in the accompanying diagram, was tested in a temperature-controlled box with MIL-O-5606 fluid for 50 hr. No attempt was made to evaluate pump life because the pump was purposely operated at very low rpm. Based on this limited test these tentative conclusions can be drawn:



1. Present systems will function satisfactorily up to 200 F, except for MIL-H-5511 flexible hose.

2. The system will probably function satisfactorily to 250 F, if leather back-up rings are replaced with teflon rings and an occasional o-ring failure can be tolerated after an extended high-temperature run. Of course, the pump would have to be qualified for the elevated temperature.

3. Replacement of the standard paper filter element with a sintered metal filter would qualify the system (except for the pump) for 300 F.

temperature range because of the inert surface of the material. Compounds are non-corrosive.

3. Inertness—Silicones resist many aircraft hydraulic fluids and lubricating oils and are chemically stable at temperatures over 600 F.

4. Unusual Surface Properties — Silicone compounds have excellent weather resistance and superior aging properties compared to most other synthetic elastomers.

Oil resistance and mechanical properties of silicone rubbers are not equal to those of organic rubbers. But definite improvement is being made. The problem of decreasing these deficiencies is being studied from two directions:

Fundamental research is being conducted to modify the silicone rubber molecule for base elastomers with enhanced properties. At the same time, the rubber compounder is working to develop new compounding materials and techniques to boost the usefulness of the basic gum now available. The effectiveness of this dual approach has been amply demonstrated with the conventional organic elastomers. In this way only is it possibe for the rubber fabricator to develop specific materials for the thousands of applications required by the aircraft industry.

In the short period of two years, the physical properties of silicone rubber have been increased from a maximum tensile strength of 800 psi and an elongation of 300% to tensile strengths of 1600 psi and elongations of 600%. Tear strength has been improved from 40 lb per in. to over 100 lb per in. Abrasion resistance is significantly improved, and by the use of better curing agents resistance to compression set has been increased. It is understood that at least one of the large silicone gum manufacturers is working on the problem of increased oil and fuel resistance. When this development is released, the hydraulics industry will have the heat resistance of silicone to help meet their problems.

Hydraulics engineers have been plagued for some time with the necessity of finding a suitable rubber for many applications involving resistance to "Skydrol" and "Pydraul." Silicones and butyl rubber blends have been only partial answers. The final answer appears to rest with a new polymer. Work is now in progress on several such projects.

It would seem reasonably safe to state that in spite of extensive work being done at this time to develop new and better polymers of the elastomeric type, the complete solution to hydraulic and pneumatic rubber problems with high temperatures is many years off. It would seem that the major portion of work to develop better rubber will fall to the rubber compounder working with the materials already available but using new compounding ingredients other than the base polymer.

Aside from a new polymer, a new plasticizer would contribute to the improvement of high temperature rubber for hydraulic applications. The di-ester type oils now being used as aircraft lubricants are presently the only rubber plasticizers with which the - 65 F low-temperature requirement can be met in many cases. If an oil with a very high boiling point can be found which will impart low temperature flexibility to high acrylonitrile type Buna N rubber when used in small quantities, the rubber compounder would have a very valuable new tool.

New antioxidants, which will inhibit aging at higher temperatures also present interesting possibilities.

Components

George R. Keller

Practically all standard commercial components for hydraulic systems are available only for use with MIL-O-5606 hydraulic oil within the temperature ranges of - 65 to 160 F. A simple change of o-rings and back-up rings has been satisfactory in adapting the components to high-temperature fluids. The modification for temperature itself is not so easy.

Aluminum alloys fall off in strength very rapidly as their temperature is raised. In particular, the strength-weight ratio becomes adverse for aluminum alloys when compared to heat-treated SAE 4130 steel at approximatey 275 F.

These facts became evident during a program aimed at learning how to operate a complex surface control servo system at high environmental temperatures for moderate time periods.

Pumps—During most of the testing, the pressure fluid was supplied by a particular kind of constant-displacement, 3000-psi pumps. No difficulty was found at temperatures between 0 and 250 F with any of the silicate fluids which were tested. At temperatures above 250 F marks of wear between pistons and housings and between piston pads and their cam plates became noticeable.

The piston wear took the form of axial scratches and scuff marks. As the operating temperatures were raised, these marks became heavier and deeper. At operating temperatures of 350 F and higher, several instances of pistons sticking tightly enough to resist movement by finger force were found.

At temperatures up to 300 F, wear between the piston pads and the swash plates showed up as polish marks on the swash plate. Above 300 F, a progressive rounding of the edges of the piston pads was noted. In its more extreme forms, this round-

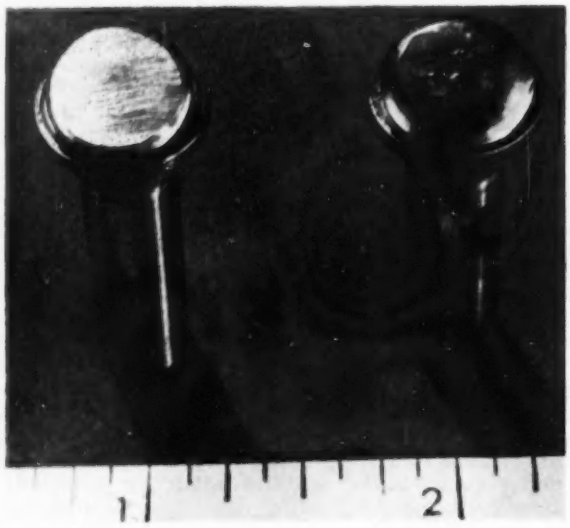


Fig. 1—Piston pads of a pump operated in a silicate-base fluid for 1 hr at 350 F

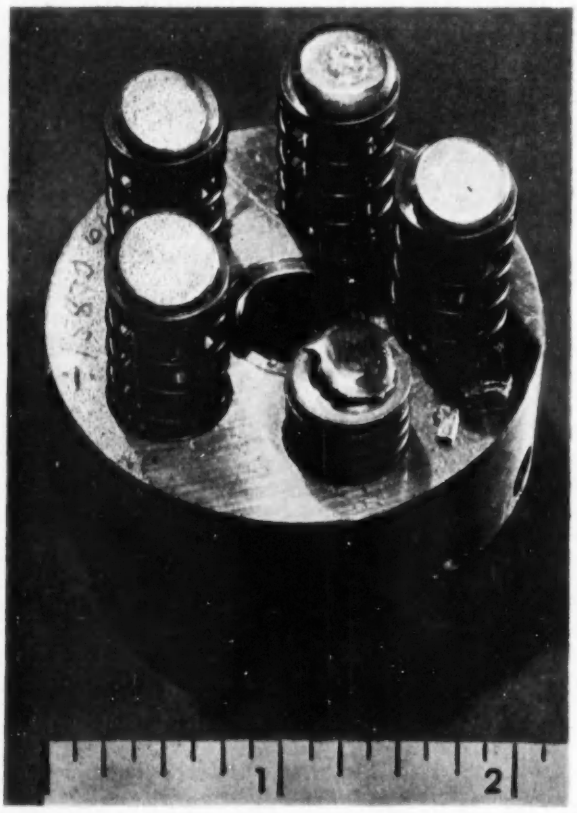


Fig. 2—Piston pads of a pump operated for 12 min at 240 F on a silicone fluid which is a poor lubricant

ing of the pads continued until the edge of the pad broke off, such as a piece might break off of a mushroomed end of a chisel. Fig. 1 shows some piston pads which had operated in a silicate-base fluid for 1 hr at 350 F. Wear marks on the pistons are clear, and a definite rounding of the piston pads can be seen. Fig. 2 is a picture of the piston pads of a pump which had operated for 12 min at 240 F using a silicone fluid, which is a poor lubricant. The rounding-off and breaking of the piston pads is very clear. The piston on which the pad is broken was stuck so firmly that it had to be pressed out of its housing. While this fluid is not one proposed for future development, this accelerated wear is illustrative of the type of trouble encountered in high-temperature operation of pumps.

The exact cause of the accelerated wear is not known. Certainly, the fluids decrease markedly in viscosity with temperature increases. For any one fluid, the lubricity of the fluid is probably nearly proportional to the viscosity. Thus, the frictional drag increases and resistance of the mechanism to wear and galling would be expected to decrease as the temperature is raised.

In addition, the strength and the modulus of elasticity of steel decrease even with moderate increases in temperature. As the pump uses springs to return the pistons, the force output of the springs probably decreases as the operating temperatures go up. This leaves a situation in which less returning force is available to move the springs against higher friction forces at the higher temperatures.

The rounding of the piston pads is probably caused by the springs' inability to return the piston before the swash plate made a full rotation. The piston pad then, rather than sliding on the swash plate, is hit a blow by the swash plate. This blow has a sizeable tangential as well as axial component of force. The rounding of the piston pad can be caused by both components of force. The tangential force, however, can put a sizeable bending load on the piston itsef. This bending load may have as great, or greater, effect on the wear and galling of the pistons as has the lowered lubricity of the fluid.

Filters—The usual phenolic-and-paper filter element tends to break down at elevated temperatures. Above 250 F bits of fiber tend to separate from the laminate and enter the hydraulic system. Also some cases of the glue which attaches the filter element to its end supports softening and yielding have been found. As a result of these difficulties, a search for a satisfactory metallic filter element was inaugurated. We are currently testing one filter which has a metallic element for which filtration of 25 micron particles is claimed. Only the metallic element from this filter is being used, the aluminum housing which is supplied being replaced with a steel body.

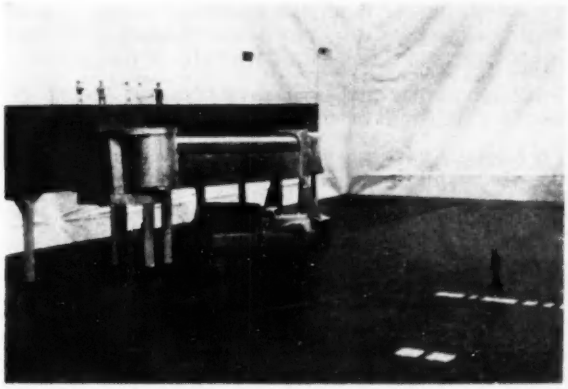
Relief Valves—At present, commercial relief valves are being modified by a simple change of seals and a change to a steel case. There is some feeling, as yet unconfirmed, that a change in spring material from steel to Inconel will be necessary to reduce difficulties caused by hysteresis in the spring.

Air Passengers . . .

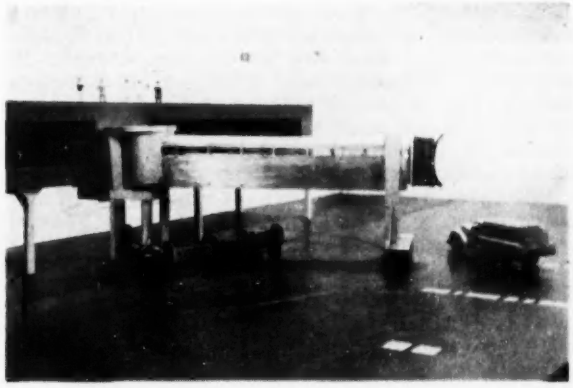
. . . need loading gangplanks for weather protection. Time saved per stop would permit re-scheduling to save millions, is claim for this design.

Henry M. Henion, Airways Engineering Corp.

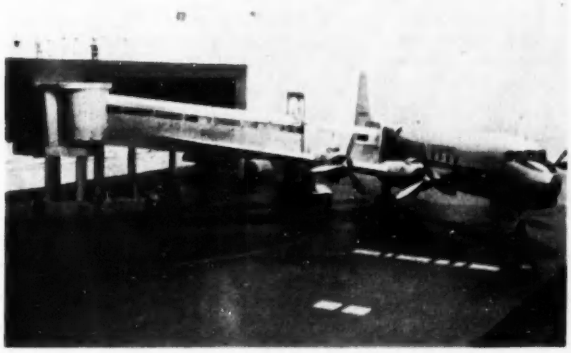
Based on paper, "Passengers Come First" presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 3, 1952.



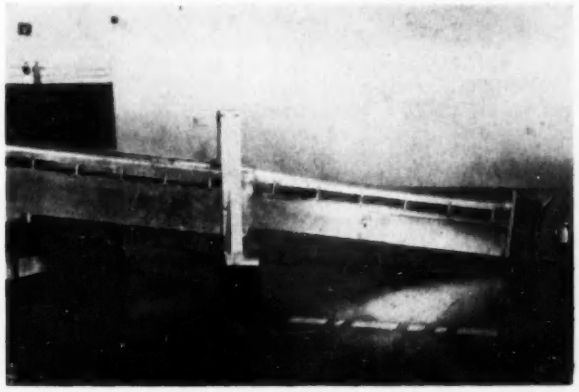
Entirely sealed from the weather, this telescoping movable gangplank awaits arrival of transport. Clearance between turret and gantry part of structure is 9 ft to permit maintenance trucks to move underneath. Turret walls are made of standard metal roller doors which wind or unwind on vertical spools. Structure is divorced from building.



Gangplank moves part way into position to meet arriving transport. Gantry rides on circular hollow track, 50 ft in radius, set flush with the apron pavement. Note the accordion-like end. This is to accommodate the various hull contours of the planes. The rectangular spring steel frame cups and conforms to the plane fuselage.



Plane moves into position. The outboard or extensible section is moved down and out to contact the plane with a thick sponge rubber sealing strip. Passengers pass through door to platform which is cantilevered from building, through turret, and down a 5-ft wide passageway. Ramp is covered with light aluminum; has 8½ ft overhead clearance.



To handle planes with retractable steps built into the fuselage, the 42-ft extensible section can be lowered to the ground. Total overall length is 94 ft. Floor between sections has 9 in. differential in level which is taken up by a sloping hinged ramp with roller bearings. A seal sweeps snow from roof of extensible section.

Rules Can Be Broken:

Zinc Die Castings

JUST because zinc costs more than aluminum and magnesium, this doesn't mean that every decorative automotive part can be die cast cheaper in aluminum and magnesium. There are other factors involved in the cost of making and finishing a die casting that can swing the balance in favor of zinc.

Actually, it's difficult to lay down a hard-and-fast rule that permits quick determination of which of the three metals will be most economical in any particular case. However, there are some general rules to help guide an engineer in deciding whether or not to substitute aluminum or magnesium for zinc in a die casting. Here are a few:

- Parts which have sharply recessed areas or which contain fine ornamental engraving should not be made in aluminum or magnesium.
- Aluminum or magnesium should not be used if design of the part does not permit polishing off fine ridges caused by long-run "heat checks" in the die.
- Backup dies are necessary if parts are to be cast in aluminum or magnesium.
- Zinc die castings can be turned out at a faster rate than aluminum or magnesium ones.

Part Design Is Important

There is a considerable difference in the type of finish that can be obtained on aluminum and magnesium on one hand and zinc on the other. Whereas most zinc die castings require no polishing operation, the same parts produced in aluminum or mag-

Table 1—Comparative Operations For Decorative Finish of Similar Zinc, Aluminum, Magnesium Die Casting

Operation	Zinc	Aluminum	Magnesium
Polishing	Parting line only	Parting line and spot polish of die cracks	Parting line and spot polish of die cracks (Fire hazard)
Buffing	All decorative surfaces	All decorative surfaces (Higher than zinc due to polishing)	All decorative surfaces (Higher than zinc due to polishing)
Plating Racks	Steel, copper or brass	Aluminum contact tip if near finished surface	Aluminum contact tip if near finished surface
Plating—Zinc Immersion Required	No	Yes	Yes
Plate Thickness Copper + Nickel	0.0005 in. inside 0.0008–0.0015 in. outside	0.00075 in. inside 0.00125–0.002 in. outside	0.00075 in. inside 0.00125–0.002 in. outside
Nickel Buffing	5–10%	100%	100%
Chromium Plating	Yes	Yes	Yes
Chromium Buffing	5–10%	5–10%	5–10%
Rejects due to porosity, blisters, and so forth	2– 3%	5–10%	5–10%

Don't Always Cost More

M. R. Caldwell and C. Pack, Doehler-Jarvis Corp.

Based on paper, "What Alloy Should Be Used to Die Cast Decorative Automotive Parts—Zinc, Aluminum or Magnesium?" presented at SAE National Passenger-Car, Body, and Materials Meeting, March 4, 1953.

nesium will need some cutting down by polishing or strapping before buffing. Table 1 shows the difference in finishing operations for the three metals.

It follows, therefore, that if aluminum or magnesium is being considered, the part must not contain any fine ornamental engraving since it would be impossible to polish such engraving without destroying the design.

It's also not practical to use aluminum or magnesium for parts which have sharply recessed areas. That's because a polishing wheel or abrasive strap could not reach these areas to cut them down before buffing.

Zinc Dies Don't Crack from Heat

With production of zinc die castings, the composition of the die steel is not of major importance providing the piece of steel is free from defects and inclusions. That's because the melting point of zinc alloy is about 750 F, at which point die steel is not affected by the thermal reactions produced in the casting process.

Things aren't so rosy, however, with aluminum or magnesium. With melting points that approximate 1200 F, the problem of obtaining a die steel which will last indefinitely has yet to be solved. Under the best conditions, "heat checks" may develop after a run of 25,000 or 50,000, depending on the size and design of the part. These heat checks are fine crevices in the die which show up on the surface of the casting as fine ridges.

Obviously, therefore, the design of the part must permit removing these ridges by polishing, since it would be economically impractical to replace the die as soon as these ridges showed up. If a polishing operation is permissible, then the die may be expected to last almost as long as a zinc die.

Need No Backup Dies for Zinc

It is standard practice to watercool a die-casting die to make possible higher production rates. In the case of an aluminum or magnesium die, this means that molten metal at approximately 1200 F is being applied to the surface of the die and, at the same time, cooling water is running through the die.

Thus there is a hazard connected with the operation of an aluminum or magnesium die that does not exist in the operation of a zinc die, namely, that a cleavage may develop and ruin the die. For this reason, it is common prudence to have a spare die on hand—a precaution which isn't necessary when die casting zinc.

Zinc Die Castings Turned Out Faster

Zinc die castings can be turned out at a faster rate than can aluminum or magnesium ones. A production rate of 300 to 500 parts per hour is not unusual for average zinc die castings. And production rates of 500 per hour or more are being obtained on thin wall and simple castings. With the higher melting points of aluminum and magnesium alloys, there are definite thermal factors which prevent such a high rate of production.

What's more, wear and tear on such die parts as cores and slides necessitates more lubrication with aluminum and magnesium die casting. This results in castings with poorer surface finish than that obtained with zinc alloys.

These are only a few of the factors that should be considered when trying to decide whether it will be zinc, aluminum or magnesium die castings. But they do serve to show that an engineer can't assume that aluminum or magnesium die castings will be cheaper just because the market price of these metals is lower than that of zinc.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Aircraft Forming

. . . from a batch of new tools, materials, and techniques. Six of the

1. Slash Handwork on Rubber-Formed Parts

Fig. 1—This shows the effect of various forming pressures on the same 0.250 in. gage 24S aluminum alloy

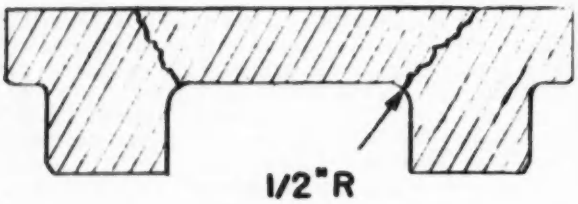


Fig. 2—High pressures can cause cracks such as this to form in rubber pad containers

ONE aircraft company found it could reduce handwork on parts formed on rubber forming presses from about 10 hr to 2 hr for every hydropress hour. Prime factors in this reduction in finish-forming costs were (1) use of higher forming pressures, (2) use of auxiliary tools that prevent wrinkling in parts with shrink flanges, and (3) mechanization of finish-forming operations by use of special equipment.

Use of higher pressures meant heavier gages could be formed or sharper detail obtained in thin gages. In the past, insufficient pressure on joggles, minimum flanges, beads, and lightening holes has necessitated considerable handwork or auxiliary tooling and a second operation. It's true that shrink flanges without auxiliary devices benefit only slightly from higher pressures except in heavier gages. However, higher pressures do open up many new possibilities.

Optimum pressures vary a great deal with material, gage, and detail design. Pressures of 2000 to 3000 psi help materially with aluminum alloys up to

Fig. 3—An auxiliary tool known as a dam helps form flanges. This illustration shows the progressive stages in forming a flanged piece using a block with a dam

Gets a Lift

roads to better and cheaper formed aircraft parts are mapped out in this article.

Donna M. Ohm, Douglas Aircraft Co., Inc.

Report on Panel on Forming held at SAE Aircraft Production Forum, Los Angeles, Oct. 1, 1952, under the auspices of the SAE Production Activity. Panel leader was O. A. Wheelon, Douglas Aircraft Co., Inc.; panel coleader was J. S. Corral, North American Aviation, Inc.

about 0.064 in., while 5000 psi or higher is required for 0.250 in. aluminum alloy. Fig. 1 shows the effect of various pressures on 0.250 in. gage aluminum. Stainless steel in moderate thicknesses profits from pressures in the vicinity of 15,000 psi, and one case of 40,000 psi was reported.

With use of pressures over 2000 psi, the majority of rubber pad containers have presented this problem: Cracks have occurred in the containers (see Fig. 2) and, in some cases, there has been complete failure of the container, resulting in personal injury or loss of life. These failures are due (1) to stress concentrations being built up in the corners and (2) to the inferior quality of the material in this region.

A round container is able to withstand higher pressures than a rectangular one, but the problem still remains. Over 2000 psi with a rectangular container and 5000 psi with a round container are considered critical.

By pointing out the problems associated with use of higher pressures, it is not meant to discourage their use . . . for benefits derived therefrom are of great importance. Rather we mean to bring about a realization of the existence of these problems.

Development of auxiliary tools to aid in finish-forming a part is also a good idea. These tools can help a great deal in reducing handwork required.

Clips are one auxiliary tool that is very useful in forming shrink flanges without wrinkles. It is difficult to state the maximum shrink that can be obtained with clips. However, on one part, 64% shrink was obtained. Clips are almost always used on soft temper material.

The dam is another auxiliary tool that helps in forming flanges. It is used to restrain the blank. A depressed bead is formed in the part as it is forced down over the block, thus preventing the flange from wrinkling. As the pressure increases, this bead is gradually pushed out until the parts fit the form block. (See Fig. 3.)

Still another way to reduce handwork is to make minor modifications in the block at die tryout. This almost always improves quality of the part and reduces its cost. Rehit operations after heat treatment on the drop hammer, draw press, and occasionally on the hydropress, also reduce handwork by practically eliminating heat-treatment warpage.

2. Heat Can Make a Forming Operation

HEAT may be the solution to many a forming problem. At elevated temperatures metals are more ductile and can be formed to more severe contours with less force. Elastic recovery is reduced so that springback is nil. What's more, the material is restored to full strength at room temperature.

The major problem centers around the dimensional change at elevated temperature. However, if the block and blank are both preheated and are of the same material, this differential expansion can be ignored.

One company recently found that to achieve best heat formability a titanium exhaust manifold shroud (see Fig. 4) should be formed at 800 to 1000 F. This part was formed in a drop hammer in a die heated to 400 to 500 F. (Keeping a die at a moderate temperature prevents the rapid cooling encountered with a cold die. If wrinkles develop, it is difficult to remove them by planishing the part when it is cold, but wrinkles are easily removed if the area is preheated.)

Lead punches and Kirksite dies were used for

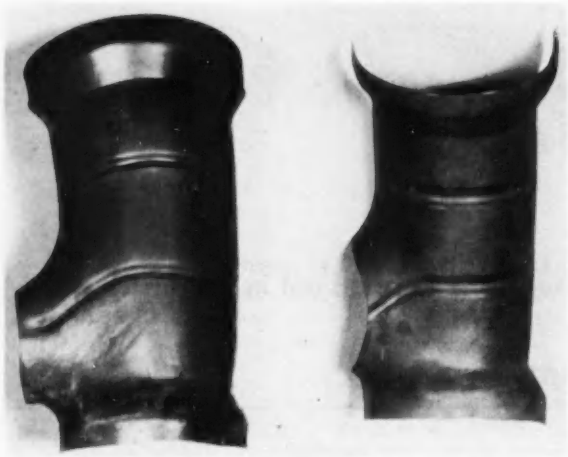


Fig. 4—This titanium exhaust manifold shroud formed best when heated to 800 to 1000 F

Fig. 5—Several stages may be built into a drop-hammer die for making small parts

limited runs, but it was found that the high temperature of the blanks tended to make them pick up lead from the punch. To overcome this, the lead punch was armor plated. For long runs, it would be better to use cast iron dies.

Heating large, unwieldly blanks prior to forming is complicated, it's true. But small parts can be torch-heated or heated in a standby furnace very nicely.

3. Never Underestimate the Powers of a Drop Hammer

TOO often the importance of drop hammers is minimized by large aircraft companies. Yet on experimental projects where speed and inexpensive tooling is essential, the drop hammer is very often an invaluable tool. Even on production jobs, it is often the most economical equipment to use.

Some parts formed in drop hammers are made in single dies with rubber used to control the flow of metal. Other parts made in drop hammers require several dies to finish-form the part, or several stages may be built into one die for small parts. (See Fig. 5.)

4. Stretch Press with Curved Jaws Stretches Dollars

THE most recent improvement in stretch presses is an adjustable jaw that curves automatically to match the transverse curvature of the form block. (See Fig. 6.) This type of jaw reduces the amount of material required in the transition area between the form block and the jaws. It also provides lower local elongation over the more severe contours.

With curved jaws, T6 stretching appears to be desirable. A recent survey made by one aircraft company showed that 95% of the parts being stretch-formed were stretched in the 24S-T3 and 75S-T6 tempers.

Another survey showed a material saving of approximately 670 lb per day or approximately $335 with a curved-jaw stretch machine (operated for two shifts).

5. Plastics Formed No Less Than Three Ways

THERE are three different ways to form plastics: mat molding, glass fiber layup, and post-forming phenolics.

In mat molding, matched metal dies are employed. The mat and resin may be formed simultaneously in the dies, or when closer control of uniform density is required, a preformed mat may be used.

In glass fiber layups, plaster mandrels are wrapped with glass fiber cloth, allowed to dry, then put under pressure in an oven at 180 to 200 F. One company recently produced a water-soluble plastic. This makes it possible to eliminate fracture of the laminate previously caused by breaking out the plaster.

Phenolics are post-formed by heating the sheet in an oven at 450 to 500 F for a few seconds, then forming in brake dies or folding-block dies. The material used must be closely controlled by specification so that it is cured properly and not over-aged.

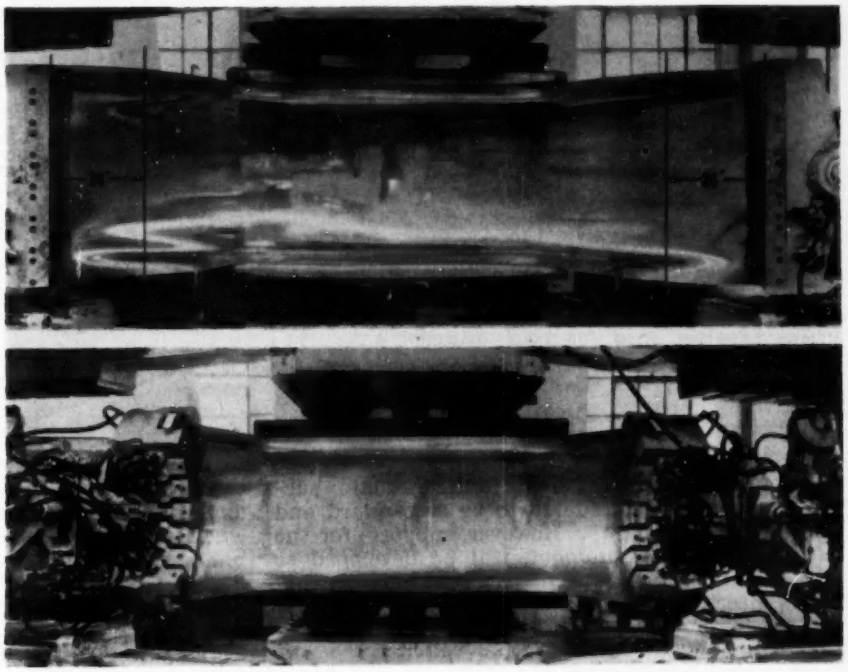


Fig. 6—This shows the most recent improvement in stretch presses: adjustable curved jaws that can match the transverse curvature of the form block

6. Straightening and Contouring Call for New Techniques

RECENT trends toward forged panels, extruded sections, and machined integrally-stiffened skins have set up a need for new techniques to overcome forming problems introduced by them.

Integrally-stiffened skins so far have been produced by milling heavy plate. But the problem of straightening and contouring these milled-in-the-flat shapes is a serious one. So far gagging on a brake and/or shotpeening have been employed to obtain necessary contours. Die quenching has been used on smaller panels.

Extruded integrally-stiffened skins have been produced experimentally in tubular form. However, slitting and flattening these shapes have presented a serious problem. An attempt at biaxially stretching these shapes produced about the maximum transverse flatness allowed by standard commercial extrusion tolerances, while lengthwise bow or straightness was within the maximum tolerance for rolled plate. A minimum of 1% permanent elongation was necessary in both directions to secure adequate flatness.

Shotpeening has been employed to put a compressive layer on one side of a member, which, in turn, causes it to bow to a convex curvature. This bow compensates the longitudinal bow which results from release of residual stresses in machining and obtains transverse contour. Because of variations in material and shape of parts, the shotpeening method of contouring is tricky and requires a great deal of skill.

An important development now accepted as a production technique is the die quenching process. Here preformed parts are heated in a furnace to solid solution temperature, placed in the die, then held under 10,000 psi pressure in the die until the part cools. Water or hydraulic fluid cools the die and part. Fundamentally this is a biaxial stretch since parts are prevented from contracting upon cooling.

No one of these methods is a cure-all for all production forming problems. Each technique has its place in the industry and, when employed properly, can reduce costs. However, there is still a need for new techniques which will more efficiently solve present forming problems and keep manufacturing costs to a minimum.

(The report on which this article is based is available in full in multilithographed form together with reports of the nine other panels held at the 1952 SAE Aircraft Production Forum. This publication, SP-300, is available from the SAE Special Publications Department. Price: $2 to members, $4 to nonmembers.)

Engineering Education in

L. M. K. Boelter, University of California, College of Engineering, Los Angeles

Based on paper "Looking Ahead in Engineering Education" presented at the Centennial of Engineering, Symposium on Engineering Education and Training, Chicago, Sept. 4, 1952.

THE four-year professional undergraduate curriculum is still considered to be a standard and has proved satisfactory. However, supports for the curriculum, five in number, will be developed so that the four years will remain a "unique segment" of engineering education.

Shorter Pre-College Education

The opinion is widespread that at least two years can be cut from the pre-college school experience of a student who has the intellectual capacity for college work and the necessary physical stamina. In other words, the material now being presented can be compressed into lesser time, or the equivalent of two years of appropriate work may be added between knidergarden and high school graduation. Canadian and European experience will help to point the way.

The subject material to be introduced in the two years saved will receive careful attention. The University of Chicago in the University College has studied intimately the recasting of knowledge, the emphasis on particular modes of reasoning, and desirable methods of instruction.

Work-Study Program

The work-study program (often called the cooperative program) deserves much more thoughtful attention and support. With a slight change in the college calendar and scheduling of all required courses each term, students may be given the opportunity of industrial employment of technical level commensurate with their maturity, training and education. An industrial (or governmental) organization will set aside one job which either two, three, or four students will serve seriatim each year depending upon the calendar. The undergraduate professional curriculum demands the support of this program for survival.

Internship Program

The Engineering profession will encourage and develop an internship program to begin directly after the award of the Baccalaureate. Certain industrial organizations have made great strides in post-graduate study for their employees, but the profession has not yet effectively and formally recognized a post-bachelor's program for the training and educating of a professional engineer. NOTE: The Engineering societies require a certain number of years of "in responsible charge" and certain State Laws require that engineers-in-training serve under registered professional engineers.

The College of Engineering, the employer and the engineer-in-training (or junior engineer) acting in concert would, in the following tentatively presented plan, arrange an individual program consisting of part or all of the following components:

1. On-the-job employee instruction by supervisors.
2. On-the-job self study.
3. On-the-job courses.
4. Off-the-job courses, socio-humanistic and technical.
5. Off-the-job self study.

The program will be designed to aid the engineer-in-training to achieve professional status, to insure more effective performance of the job assignments during the training program, and to fill such gaps in general knowledge and specific applications as will allow the most effective discharge of his duties as a citizen.

The climax of this internship program will be an examination or/and dissertation based upon the total training and educational experiences of the candidate for the previously selected period (say four to five years). Initiation of this program at an early date is imperative to the future well-being and strength of the profession.

Post-Graduate Education

The post-graduate education of the engineer-in-training and the professional engineer will receive attention through an intensified adult education program, sponsored by Engineering Extension. There will be available technical courses designed to (a) broaden the engineer, (b) specialize his experiences, and general courses designed to give depth and meaning to his contributions to society. Correspondence courses to meet specific needs will be had more generally. Techniques will be designed to aid the engineer located in remote places. En-

the Future

gineering society publications will be utilized to increase the pertinence of the post-graduate experience.

Graduate Program

A dynamic graduate program leading to either Science or Engineering degrees is in a virile growth stage. Graduate work in Engineering assumed a master-pupil relationship in early days with emphasis on the original individual investigation. Accompanying its growth will come recognition that a change in instruction method is necessary. Courses are now replacing seminars, instructors are undertaking the direction of many research projects; the result, in many instances, has led to graduate work becoming either an image of undergraduate instruction or a retention of the master-pupil relationship but on a larger scale. In either case the effectiveness of the instructional methods must be examined.

Graduate students may wish to obtain a foundation for the practice of the Engineering of Tomorrow for which a knowledge of the modern concepts in the Physical and Life Sciences is essential. Others may wish to broaden their engineering base, and still others to specialize in a branch or phase of engineering. Combinations of the three objectives are possible, although resulting in a dilution.

As graduate work in engineering becomes an accepted part of the training and education of the professional, the present dichotomy will be resolved through the development of two paths toward advanced degrees. M.S. or Ph.D. degrees (or equivalent) will be directed toward the discipline of research, with emphasis on the techniques of analysis and with the subject objectives either chosen to decrease the gap between the Physical and Life Sciences and Engineering, or selected to broaden the student's background in engineering.

The clearly professional stem, leading to Master of Engineering and Doctor of Engineering degrees, will be directed to the discipline of the design of engineering systems with emphasis on the techniques of synthesis and with objectives of either broadening or deepening the students background in engineering. This graduate experience may be designated as existing in Engineering as an Art, strongly supported by Engineering Science. In both paths the methodology of engineering will be used and greater emphasis will be placed on its socio-humanistic content.

Flow of Information

As an educational center the engineering college is a component in a flow circuit. Knowledge flows outward through the undergraduate student, graduate student, faculty consultation, faculty texts, and technical publications. Such channels as the newspaper, house organ, radio and television have not been exploited adequately, but they will be used by the professional engineer more effectively within the next generation.

The return flow path from industry and the field to the engineering school has not been established as a conscious effort. Catalogs, advertisements, house organs, sectioned and working models serve only as a partial return path.

A function of industry is to utilize knowledge, which process will generate further knowledge; in sum, the function of utilization results in the generation and diffusion and differentation of knowledge. Information must flow back to the college where it should be formulated, integrated and generalized. Still further fragmentation of knowledge by the engineering college will be considered indefensible. Herein lies a research task appealing to the imaginative instructor.

Industrial Functions

Industrial functions of import to the engineer and often cited are design, research, development, production, construction, sales, service, maintenance and others. But these have not yet been carefully defined. What, for instance, are the disciplines of the design function? Does a universal design methodology exist? The attention of professional engineers and of teachers will be directed to the problem of establishing the meaning of the design function and to develop its methodology. Again, the existing experimental data will be sifted and further data will be gathered in order that the production and construction functions (and others) may be placed upon an analytical basis. Herein lies one of the greatest challenges to engineering educators.

TECHNICAL COMMITTEE *Progress*

Hydrodynamic Drive Symbols Are Approved

A COMPILATION of symbols for use with hydrodynamic drives has been approved by the SAE Technical Board.

The list was drawn up by a subcommittee of the SAE Hydrodynamic Drive Committee with the idea that standardization of symbols in technical reports and papers on hydrodynamic drives would make them easier to follow. Oliver K. Kelley of General Motors Research was chairman of the subcommittee.

The symbols are contained in the SAE Recommended Practice on Symbols for Hydrodynamic Drives, which is scheduled to appear in the 1954 SAE Handbook.

The recommended symbols are:

A ..... area, net, normal to axial plane (square feet)
A_g ..... area, gross, between shell and core normal to axial plane (square feet)
a ..... blade exit angle (degrees)
a' ..... blade entrance angle (degrees)
B ..... width of channel, projected width of blade (inches)
b ..... relative exit angle (degrees)
b' ..... relative entrance angle (degrees)
C ..... coefficient
d ..... density (pounds per cubic foot)
E ..... efficiency (percent)
F ..... fluid velocity in axial plane, torus flow (feet per second)
g ..... gravity constant (32.2 ft per sec per sec)
H ..... head (feet)
h ..... thickness of blades (inches)
hp ..... horsepower
K ..... capacity factor
M ..... mass flow (poundals per second)
Mm ..... moment of momentum
m ..... mass density (poundals per cubic foot)
N ..... revolutions per minute
n ..... speed ratio
Q ..... quantity of flow (cubic feet per second)
R ..... radius (feet)
S ..... spin, whirl, or tangential velocity, tangential component of absolute velocity (feet per second)
T or T_q ..... torque (pound feet)
t ..... torque ratio
U ..... physical velocity, linear velocity of a point on a blade (feet per second)
V ..... absolute velocity (feet per second)
W ..... relative velocity (feet per second)
w ..... angular velocity (radians per second)
Z ..... number of blades

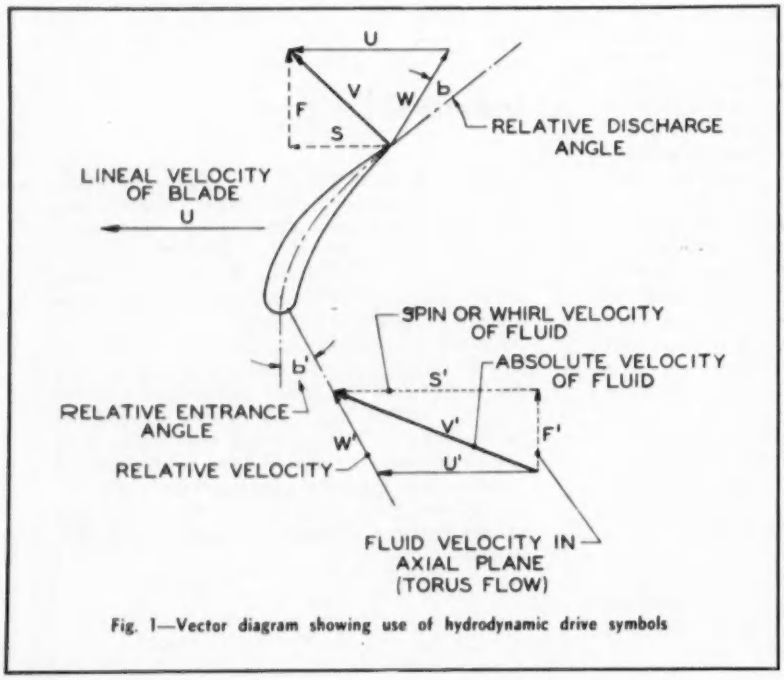


Fig. 1—Vector diagram showing use of hydrodynamic drive symbols

Fig. 1 explains the relation of these symbols to the vector diagram. The list and diagram will appear in the Recommended Practice together with a table showing application of subscripts. Recommended subscripts are: for the first pump, **P1**; for the first impeller, **i1**; for the second pump, **P2**; for the first turbine, **T1**; for the second turbine, **T2**; for the third turbine, **T3**; for the first stator, **S1**; for the first reactor, **R1**; for the second stator, **S2**; for the second reactor, **R2**.

H-Bands Narrowed Toward Quenched End

MOST SAE-AISI hardenability bands are in the process of being redrawn about 1 Rockwell C hardness unit narrower at the 1/16 and 2/16 points. This will give steel users the benefit of more closely controlled hardenability in thin sections.

The narrowing of the bands was made possible by recent authorization of narrower carbon ranges of all steels and widened manganese and chromium ranges for single and double alloy steels. The revisions are being made on the basis of data from over 40,000 heats of steel.

In the case of certain carbon steels having 0.30 or 0.32% carbon content,

recent data show generally higher hardnesses at the 1/16 point than the original charts indicate. For these steels, both the minimum and maximum bands are being raised a little.

The revision of the hardenability charts is scheduled to be completed in time for the new charts to go into the 1954 SAE Handbook.

Division III—Hardenability Bands of the SAE Iron and Steel Technical Committee is supervising the H-band revision.

Technishorts . . .

LATHE CHUCKS—The American Standard, "Chucks and Chuck Jaws," has been revamped. Not only has it been revised to include specifications for chucks for engine lathes with Type I spindle noses, but its author committee has clarified and simplified all the material and illustrations in this document.

ASA Sectional Committee B5, Small Tools and Machine Tool Elements, gets credit for this job which has just been approved by the SAE Technical Board. (SAE is one of the sponsors for this sectional committee.)

CORRECTION—The table of ball and roller bearing tolerances on page 672 of the 1953 SAE Handbook reads in ten-thousandths of an inch, not in thousandths as the table title says. The mislabeled material is Table 17 of the SAE Standard on Ball and Roller Bearings.

ASA D7 ON INSPECTION—T. J. Carmichael has just been named SAE representative on Sectional Committee D7 on Inspection Requirements for Motor Vehicles of the American Standards Association. Stephen Johnson Jr. and L. L. Beltz were named alternates. Carmichael is with General Motors Proving Ground, Johnson with Bendix-Westinghouse Automotive Air Brake, and Beltz with Ford.

S-2 Starts New Projects

MILLER Wachs, chairman of S-2, the Helicopter Committee, has announced the names of the members appointed to two new subcommittees, as follows:

1. Nomenclature Subcommittee: F. G. Weber of Kaman Aircraft, chairman; G. Niemeyer, Sikorsky; B. Coleman, Hiller Helicopters; and C. C. Hurlburt, Piasecki.

2. Helicopter Wheels, Tires, and Brakes: V. W. Sahi of Kaman Aircraft, chairman; and Dave Grant, Hughes Aircraft.

The scope of the Nomenclature Subcommittee is limited to the establishment of names and nomenclature for items generic to the helicopter industry.

The Wheels, Tires, and Brakes Subcommittee was formed because the members of the committee feel that the braking problem is different for helicopters than for other aircraft. Helicopters need good static holding brakes, but do not require high energy absorption capacity. In addition, it would appear that wheels and tires should be designed to meet the same limiting loads. In carrying out this assignment, it is expected that such factors as soil modulus may have to be considered.

In order to maintain a steady level of activity, the committee has also

A full bill of fare kept these members of SAE Committee AE-1, Joint Aircraft Engine and Accessory Installations, stepping at their June 9-10 meeting. As guests of Glenn L. Martin Co., they got a chance to inspect the engine installation and systems serving the engines in Martin's B-57 (Canberra) and P5M-1 planes. Then, after observing a Sapphire jet engine on test (see above), they ensconced themselves in a Martin-provided meeting room and went to work discussing and solving mutual problems

decided to have each member designate an alternate. The following alternates have been appointed: A. A. Coronato, Sikorsky; Kenneth Gillmore, Piasecki; M. L. Stevens, Kaman Aircraft; Lew Graham, Bell; H. S. Campbell, Eastern Rotorcraft; Don N. Meyers, Piasecki; Raymond Landis, Prewitt Aircraft; Harold Hirsch, Hughes Aircraft; R. Jackson Harter, Aircraft Division, McCulloch Motors Corp.; Joseph Stuart III, Hiller Helicopters; and Tom Zeerip, Doman Helicopters.

New and Approved Aero Materials Specs

SIXTEEN new and revised SAE Aeronautical Materials Specifications are currently being circulated to industry for comment and criticism by the SAE Aeronautical Materials Specifications Division. Copies of these specifications are available for review from the SAE Aeronautical Department.

The SAE Technical Board has recently approved 13 new specifications and 16 revised ones.

Specifications under review are:

- AMS 3034A—Aviation Fuel, Grade 108/135
- AMS 3170B—Thinner, Alcohol—Ester
- AMS 3274A—Synthetic Rubber Sheet, Nylon Fabric Reinforced Aromatic Fuel Resistant
- AMS 4018—Aluminum Alloy Sheet and Plate, 3.5Mg-0.25Cr (54S-O)
- AMS 4019—Aluminum Alloy Sheet and Plate, 3.5Mg-0.25Cr (54S-H32)
- AMS 41XX—Aluminum Alloy Forgings, 1.0Mg-0.6Si-0.25Cr (61S-T6)
- AMS 4285—Aluminum Alloy Castings, Centrifugal, 7Si-0.3Mg (356-T6), Solution and Precipitation Treated
- AMS 4362—Magnesium Alloy Forgings, ZK60-T5, Precipitation Heat Treated
- AMS 5315—Iron Castings, Nodular, 60,000 psi Tensile
- AMS 5316—Iron Castings, Nodular, 80,000 psi Tensile
- AMS 5361B—Steel Castings, Sand and Centrifugal, Corrosion and Heat Resistant, 18Cr-13Ni-2.1Mo
- AMS 5542D—Alloy Sheet, Corrosion and Heat Resistant, Nickel Base 15.5Cr-7Fe-2.5Ti-1(Cb + Ta)-0.7Al
- AMS 5667D—Alloy, Corrosion and Heat Resistant, Nickel Base-15.5Cr 7Fe-2.5Ti-1(Cb + Ta)-0.7Al
- AMS 5668D—Alloy, Corrosion and Heat Resistant, Nickel Base-15.5Cr 7Fe-2.5Ti-1(Cb + Ta)-0.7Al
- AMS 5724—Steel, Corrosion and Heat Resistant 20Cr-9Ni-1.6Mo-1.4W-Ti
- AMS 6354—Steel, Sheet and Strip, 0.75Si-0.6Cr-0.2Mo 0.1Zr (0.10-0.17C)

Specifications approved by SAE Technical Board are:

- AMS 2211A—Tolerances, Magnesium Alloy ZK60A Extrusions
- AMS 2403B—Nickel Plating
- AMS 2645B—Fluorescent Penetrant Inspection
- AMS 3212G—Synthetic Rubber, Aromatic Fuel Resistant
- AMS 3620A—Plastic Moldings and Extrusions, Polystyrene
- AMS 3640A—Plastic Moldings
- AMS 3720—Paper Honeycomb (60 lb. Paper)
- AMS 3722—Paper Honeycomb (125 lb. Paper)
- AMS 3825—Fabric, Glass (181) (Chrome Treated)
- AMS 3835—Fabric Glass (181) (Decorative Grade)
- AMS 3836—Fabric, Glass (182) (Decorative Grade)
- AMS 4048A—Aluminum Alloy Sheet and Plate, Aluminum Alloy Clad
- AMS 4049A—Aluminum Alloy Sheet and Plate, Aluminum Alloy Clad
- AMS 4086D—Aluminum Alloy Tubing, Hydraulic
- AMS 5080C—Steel
- AMS 5351B—Steel Castings, Sand, Corrosion and Moderate Heat Resistant
- AMS 5513—Steel Sheet and Strip Corrosion and Heat Resistant
- AMS 5639—Steel, Corrosion and Heat Resistant
- AMS 5676—Alloy Wire, Corrosion and Heat Resistant, Nickel Base
- AMS 5698—Alloy Wire, Corrosion and Heat Resistant, Nickel Base
- AMS 5699—Alloy Wire, Corrosion and Heat Resistant, Nickel Base
- AMS 5677 — Welding Electrodes, Coated, Alloy, Corrosion and Heat Resistant, Nickel Base
- AMS 5691B — Welding Electrodes, Coated, Steel, Corrosion and Heat Resistant
- AMS 5783B — Welding Electrodes, Coated, Steel, Corrosion and Heat Resistant
- AMS 5785B — Welding Electrodes, Coated, Steel, Corrosion and Heat Resistant
- AMS 5795B — Welding Electrodes, Coated, Alloy, Corrosion and Heat Resistant, Iron Base
- AMS 6302—Steel, Low Alloy Heat Resistant
- AMS 7271—Rings, Sealing, Synthetic Rubber
- AMS 7472C—Bolts and Screws, Steel, Corrosion Resistant, Roll Threaded

Why 12 Volts for Cars

Excerpts from paper by

H. L. HARTZELL

Delco-Remy Division, GMC

A 12-volt electrical system on passenger cars would fulfil the need for better ignition performance, higher generator output, and faster cranking speed.

It would do this with the same distributor, the same size coil, the same size generator, and the same size cranking motor.

Battery size would be increased 5%, it is true, but energy storage capacity would be boosted 30%.

All in all, 12-volt systems should keep drivers going down the road—rather than standing in service stations. (Paper, "The 12-Volt Story," was presented at SAE Mid-Michigan Section Meeting, Owosso, March 3, 1953.)

Tests Non-Sludging Ability of Lube Oils

Based on paper by

J. G. McNab
M. E. Conn
D. S. McArthur
and
K. L. Stehle

Standard Oil Development Co.

TO study sludge formation under low-temperature, stop-and-go conditions, a procedure was developed which measures the sludge handling ability of oils in terms of the time required to reach 50% oil screen plugging in cyclic laboratory engine operation. Equipment used in this S.O.D. test was essentially the same as used in the FL-2 test, except that piston ring gaps were increased from 15 to 30 thousandths of an inch to increase blowby to the crankcase.

Four lubricants and two fuels were used. Of the latter, one was a special experimental, high deposit type, designed to give heavy sludge under the low temperature conditions, and the other was of the low deposit, relatively clean burning type.

Field tests were also run, using a fleet of door-to-door delivery trucks, powered by similar make engines, and operating on like fuels and oils.

The manner of sludge buildup in test and field was found to be almost identical. Very little sludge is formed initially. Then there is a breakpoint

and sludge forms rapidly until the screen becomes almost completely plugged. If one hour of operation in the laboratory test is equated arbitrarily to 50 miles of operation in the delivery trucks, a single line can be plotted through laboratory and field results. The only important difference between laboratory and field engines appears to be in rate of buildup. (Paper, "A Low Temperature Sludging Test," was presented at SAE Annual Meeting, Detroit, Jan. 16, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

Based on Discussion

A. C. Pilger, Tidewater Associated Oil Co.

Is oil screen blocking per se the direct cause of oil starvation and engine failure or is it a preliminary stage which precedes rapid restriction of oil passages when deposits are no longer removed from the oil as it passes the screen? Couldn't the test be shortened by arbitrarily concluding it when the oil screen is only 10% blocked?

McNab:

Data were insufficient to determine whether screen plugging was a cause or a preliminary stage. Tests could be shortened to the 10 or 20% blocked point. We used 50% to be certain we were beyond the breakpoint of the curve which relates hours of test to percent of plugging.

L. A. McReynolds, Phillips Petroleum Co.

Were correlations observed between laboratory and field oil ring plugging? What were the magnitude and consistency of blowby measurements which may have been recorded?

McNab:

We observed that no appreciable plugging of the oil control rings occurs until some time after considerable amounts of sludge have accumulated on the oil screen. As I recall, blowby measurements were not particularly consistent and therefore were considered of no great value.

H. C. Mougey, General Motors Corp.

Has the new test procedure ever been applied to synthetic lubricants such as the polyalkylene oxide type?

McNab:

Yes, the polyalkylene oxide type was evaluated and found to give very excellent results.

W. F. Ford, Continental Oil Co.

Is it believed that any of the cylinder wear in the laboratory test engine is of the corrosive type? What are sludge numbers and hydrocarbon types of the fuels used?

McNab:

We are quite certain that under operating conditions specified in our test procedure, a substantial part of

Continued on Page 109

SAE Section Meetings

Section Golfs At Country Club

• Canadian Section

June 18—Members and guests of the Canadian Section enjoyed a day at the Westmount Golf Club, Kitchener, Ontario. Competitions gave all golfers, "good and otherwise," a fair chance. Foursomes were arranged by members themselves, or by a committee if desired.

Besides the tournament and an evening dinner, described as "the grand finale," everyone had an opportunity to win prizes and enjoy "fellowship and fluid preservatives." There were no speeches! The only serious business was the special meeting of the governing board before noon.

Speaks of Progress Of Power-Steering

• Texas Gulf Coast Section

W. B. Tilden, Field Editor

June 12—**Edward L. Asch,** district manager for Vickers, Inc., Houston, presented his paper, "Power-Steering" before the Texas Gulf Coast Section.

Using lantern slides and cut-away models to supplement his talk, Asch said that power-steering installations in the passenger-car field were very few prior to 1950, that at that time there were only about 10,000 units produced for passenger-car service. However, when Chrysler announced late in 1950 that the '51 models would have power-steering, this caused other manufacturers to unveil their plans for such applications also. Because of this rush to power-steering, by the end of 1952 over 200,000 units had been produced and the majority of these units were passenger-car installations, he said.

In tracing the origin of power-steering, Asch said that it is not new to man. There were many of these installations years ago on heavy trucks and earth-moving equipment, he said.

The present hydraulic approach was developed in 1920 and by 1930 standard production units were available. During the 20's, automobile manufacturers were not interested in power-steering; nevertheless, the truck industry was gradually installing more and more units. World War II saw many applications and created a chance for people to become familiar with its benefits.

Speaking about the advantages of power-steering, Asch said bus and truck drivers as well as passenger-car drivers can, with the aid of this steering assist, reduce fatigue and at the same time enjoy greater comfort and safety. With power-steering on heavy truck equipment, it is possible to place greater loads nearer to the front axle so that the vehicle can legally carry greater over-all loads.

Asch warned that although power-steering can be added to any truck or existing passenger-car at the present time, it is preferable to purchase a car with a factory-engineered installation.

SAE Student News

University of British Columbia

The SAE Student Branch at University of British Columbia continued to be the largest student branch in Canada during the 1952-53 school year, despite reduced membership; also the group was in close competition with U. S. universities.

The reduction of members was a result of fewer students entering the engineering field at the university. During the past most members have been drawn from the mechanical engineering department. However, an effort is being made to interest chemical, metallurgical and electrical engineering students as well.

The group which has bi-weekly meetings and one night a month outings, has given its SAE Handbook to the mechanical engineering library where it is in constant use as a reference for design assignments. The Journal is placed in the engineers' library with the hope that it will introduce junior engineering students to the Society.

Airplanes and automobiles are the chief interests of the British Columbia students, and films dealing with these subjects attract large audiences. Movies are obtained from local offices of General Motors, Finning Tractor and Equipment Co., and other companies.

Speakers in the past year have included: Edward W. Rentz, West Coast manager of the SAE Journal; Gilbert Way of the Ethyl Corp. and an SAE member; Wilton Gibson of the Twin Disc Clutch Co.; F. W. Vernon, professor in the mechanical engineering department at the university; Harold Puxon, member of the SAE and managing-director of the Columbia Trailer Co., Vancouver; Burdette Trout, secretary of the British Columbia Section who is with Truck Parts & Equipment, Ltd., Vancouver.

The highlight of the year's activities was the annual student night meeting held Feb. 16. It was completely organized and conducted by the students. A dinner was served and an after-dinner talk was given by fourth-year mechanical engineering student, Jim Strain. The theory of rockets was the subject of a paper presented by Dr. G. V. Parkinson of the mechanical engineering department. One-hundred guests were then taken on a tour through the mechanical and metallurgical laboratories. A great success, the meeting went a long way toward enhancing the branch's reputation with both the university and the SAE Section in British Columbia.

—W. A. Graham Bell, Chairman

San Diego State College

More than 100 San Diego SAE members and San Diego State College Student Branch members met May 9 on the campus for their annual engineering banquet in the physical science auditorium, planned by George Swanson, student chairman. "Development in Engineering at S.D.S.C." was the talk by **Dr. Dudley H. Robinson,** chairman, division of physical science. Dr. Robinson illustrated his talk with a large map of the college and a cut-out floor map of the addition soon to be a part of the physical science and industrial arts buildings.

Dr. Robinson said bids will be out in a few months for this building which will cost approximately $350,000. New equipment planned will be about $90,000. The engineering department will then include 14,600 square feet.

California is training a smaller number of engineers than any other state, Dr. Robinson said, and in San Diego the need is especially great. During World War II, one engineer was needed for every fifty men and now one engineer is needed for each ten men. Approximately 150,000 engineering man hours were required for production of a pre-war bomber. Now several million are required, according to Dr. Robinson.

About 21,000 engineers are being graduated each year, he said. The normal demand is 30,000 engineers a year, plus 12,000 for defense, a total of 42,000.

S.D.S.C. is expanding its work experience program in jobs directly related to training with students in the program at Consolidated Vultee Aircraft Corp. Ryan Aeronautical Co. may soon be included in the program, Dr. Robinson said. More subjects are to be added to the curriculum, such as technical report writing and more speech, finance and business courses applicable to engineering.

This past year at the college found a large freshman class in engineering, bringing the total to 350 engineering majors. S.D.S.C. is encouraging better high school education to prepare for engineering.

California State Polytechnic College

Probably the SAE Student Branch at California State Polytechnic College was one of the most active branches this past year. Of their twelve regular meetings, nine featured technical speakers. A three-day field trip was made to visit industry in the Los Angeles area, and Du Pont's fuel road test car was featured in an exhibit during the college's annual open house.

On the lighter side, the students held a dinner jointly with the mechanical engineering club at which Ralph De Palma, famous race car driver, was speaker. A social meeting was held with the Young Farmers Club, and a spring barbecue that had an attendance of about 100 persons were also included in the year's schedule.

Dave McKinley, chairman, received the Mac Short Memorial Award presented each year by the Southern California Section of SAE.

Officers for the 1953-54 school year were elected and another prosperous year is expected under their leadership. They are: Stanley D. Adkins chairman; Robert E. Aronstein vice-chairman; Frank E. Tippets secretary; and James H. Schield treasurer.

—Dave McKinley, Chairman

General Motors Institute

The monthly meeting of the SAE Student Branch at General Motors Institute held June 30 came to an abrupt halt during a severe storm.

A chassis dynamometer demonstration was being presented using an elaborately equipped test car when the power failed because of the storm. Owned by the Petroleum Chemicals Division of E. I. Du Pont de Nemours & Co., the car was being operated by Paul Richard, an SAE member, and James Trexel, both of Du Pont.

Prior to the demonstration John Egan, automotive engineer for the Standard Oil Co., Indiana, presented his paper, "Octane Rating of Automotive Fuels."

—Frank H. Walker, Chairman

Los Angeles Production Forum Takes Shape

NEWS OF SAE

Members of panels of the 1953 SAE Aircraft Production Forum are putting the finishing touches on their plans for their meeting. This Production Forum will be held at the Hotel Statler, in Los Angeles, Sept. 29-30, in conjunction with the SAE National Aeronautic Meeting.

Pictured above is the Change Control Panel, which recently met at Douglas Aircraft, in Santa Monica. Standing (left to right) are: J. C. Derse, administrative assistant to manager of manufacturing planning, AiResearch Mfg.; H. E. Herdrich, assistant manager, industrial and plant engineering, Northrop Aircraft; Panel Secretary D. C. MacArthur, general supervisor, schedules and change control, Douglas Aircraft.

Seated (left to right) are: Panel CoLeader A. F. Kitchin, production manager, Rohr Aircraft; E. W. Rentz, SAE staff; J. F. Lashley, chief project coordinator, patrol series, Lockheed Aircraft; J. R. Allen, general supervisor, schedules and change control, Douglas Aircraft; and Panel Leader N. H. Shappell, manufacturing control manager, Douglas Aircraft.

Bornstein Reports on Israel Visit

EVERYBODY works hard in Israel, Hyman Bornstein told an informal gathering of members of the executive committee of the SAE Iron and Steel Technical Committee at Atlantic City. Bornstein, new ISTC chairman, had just returned from a three-month visit to Israel as a United Nations-sponsored metallurgical consultant.

The Israelis have to work hard, Bornstein emphasized, to provide for their immigration-increased population and to patrol their 800-mile border. Some Israelis belong to kibbutzim—collective farms complete with communal kitchens and nurseries so that women are free to work along with the men at farm and factory duties. Other agricultural workers live and work on cooperative farms or on their own small farms. And thousands of workers are employed in privately owned industries that are springing up.

Hyman Bornstein

Both boys and girls when they reach the age of 18 go into the army for two years, Bornstein reported. They continue to be liable for one month of service each year through middle age.

Bornstein feels that one of the things Israel needs most now is peace with its Arab neighbors. When real peace replaces the current armed truce, Israel will be free to shift a considerable part of its effort from military preparedness to more productive enterprise. Then, too, perhaps visitors will be permitted to visit both Israel and the Arab countries—making the whole area more attractive to tourists than it is now that they cannot get visas to enter both Israel and Arab countries on one trip.

A Newspaperman Looks at SAE . . .

(From the column "World on Wheels" by Leo Donovan of the Detroit Free Press)

WORLD of WHEELS

BY LEO DONOVAN
Free Press Automotive Writer

An appraisal of the Society of Automotive Engineers must take into consideration the really great volume of work the organization performs in a year.

After a week's session with the SAE in Atlantic City, most trade journal writers come away with enough material to write about for months.

There were, for instance, three major symposiums (or should it be symposia?), 11 round table discussions, a panel meeting, 31 learned papers read and 39 committee meetings in the space of five 13-hour days.

Obviously, all of the engineers could not attend all of these sessions, and on the plane home I observed one reading a paper that had been delivered four days earlier. He may have been one of those who found time to take part in the program's sports and social events which included golf, surf bathing, deep sea fishing, dancing and cocktail parties.

SAE officials guessed that there were about 2,000 in attendance at the various sessions, most of them from Michigan. The controversial meetings were well attended, but in a few of the parlors we noted only small audiences.

* * *

THERE WAS AN awful lot of scientific information to share among the engineers, some of which probably never will be used again.

But in the various suites, long discussion was held that never will appear in the SAE Journal, but will be important to engineers.

Here is where they argue at great length about ratios and the inevitable optimum performance of their gadgets. Here is where the engineers learn who is going to do what among their competitors on forthcoming models. Here is where they discuss such sacred, or at least, secret, stuff as cost and price and time schedules.

How they divide their day to get as much done as they do at these conventions is a mystery even the engineers can't explain.

PROGRAM . . .

. . . for Fall Diesel Meeting is almost complete. Papers for three sessions announced.

PLANS for three of the four sessions of the 1953 National Diesel-Engine Meeting have been completed, according to H. W. Luetkemeyer, meetings vice-chairman for the SAE Diesel-Engine Activity.

At the June 11 meeting of the Activity, held in Atlantic City during the SAE Summer Meeting, he reported that the following papers were definitely planned for the meeting:

1. "Gas Turbine Locomotive Operating Costs and Performance," by P. A. McGee, consulting engineer.

2. "Scavenging of 2-Stroke Engines (covering over 10 years of research in this field at M.I.T.)," by C. F. Taylor and A. R. Rogowski, M.I.T.

3. "Development of an Improved Automotive Diesel Combustion System," by Bruno Loeffler, Mack Mfg. Co.

4. "Development of Light-Weight Marine Diesel for Navy," by Marsden Ware, Packard Motor Car Co.

The meeting is to be held November 3 and 4 at the Conrad Hilton Hotel in Chicago.

PROGRESS . . .

. . . cited for large forgings and extrusions despite many unknowns.

LARGE forgings and extrusions will be working their way into aircraft at an increasing rate. That's the implication most engineers took away from the two technical sessions devoted to the heavy press program at the ASME Semi-Annual Meeting at the Hotel Statler, Los Angeles, last month. These sessions were cosponsored by SAE, IAS, and ASME.

Use of these parts is on the rise because:

1. Designers are learning more about their potential and have pretty well defined what they know and don't know.

2. The capacity of new presses implies an ability to produce larger forgings. Even existing

presses are showing capabilities of producing thinner webs and smaller draft angles.
3. The increasing availability of heavy press forging and extrusion capacity will tend to promote use of large forgings and extrusions.

However, it's not all clear sailing yet. Much fog remains to be dispelled. C. W. Andrews, of Douglas, pointed out that no general statements can be made as to tolerances, die closure, die deflection, straightness, flatness and other variations. Size and thickness variations are not known.

Andrews feels that designer and producer have to tread cautiously together in coordinating airframe requirements and forging producer capabilities. A. E. Favre, of Alcoa, says this kind of cooperation is the only way to make headway with the heavy press program.

National Meetings . . .

Meeting	Date	Hotel
	1953	
INTERNATIONAL WEST COAST	Aug. 17-19	Georgia Hotel, Vancouver, B. C.
TRACTOR and PRODUCTION FORUM	Sept. 14-17	Hotel Schroeder, Milwaukee
AERONAUTIC MEETING, AIRCRAFT PRODUCTION FORUM, and AIRCRAFT ENGINEERING DISPLAY	Sept. 29-Oct. 3	Hotel Statler, Los Angeles
INTERNATIONAL PRODUCTION	Oct. 29-30	Royal York Hotel, Toronto
TRANSPORTATION	Nov. 2-4	The Conrad Hilton, Chicago
DIESEL ENGINE	Nov. 3-4	The Conrad Hilton, Chicago
FUELS and LUBRICANTS	Nov. 4-6	The Conrad Hilton, Chicago
	1954	
ANNUAL MEETING and ENGINEERING DISPLAY	Jan. 11-15	The Sheraton-Cadillac Hotel and Hotel Statler, Detroit
PASSENGER CAR, BODY, and MATERIALS	March 2-4	Hotel Statler, Detroit
PRODUCTION MEETING and FORUM	March 29-31	The Drake, Chicago
AERONAUTIC MEETING, AERONAUTIC PRODUCTION FORUM, and AIRCRAFT ENGINEERING DISPLAY	April 12-15	Hotel Statler, New York City
SUMMER	June 6-11	The Ambassador, Atlantic City, N. J.
WEST COAST	Aug. 16-18	Hotel Statler, Los Angeles
TRACTOR and PRODUCTION FORUM	Sept. 13-16	Hotel Schroeder, Milwaukee

Program for

SAE National Tractor Meeting and Production Forum

Hotel Schroeder, Milwaukee, Wis. Sept. 14-17, 1953

PRODUCTION FORUM

Sponsored by SAE Production Activity

Sponsor—W. A. Roberts, President, Allis-Chalmers Mfg. Co.
Chairman—N. P. Mollinger, The Ladish Co.

10:00 a.m. to 12:00 Noon—2:00 p.m. to 4:00 p.m.

Seven separate informal gatherings to exchange information and experience on vital production problems. Each will be sparked by a panel of experts as shown.

Monday, Sept. 14

QUALITY CONTROL . . . How to Get the Most Out of It

This session will focus on:
- Source inspection
- Receiving inspection
- Statistical quality control applications
- Equipment for quality control
- Organizing quality control to assist your vendors
- Quality control techniques for short-run jobs

Panel Leader:
R. S. Saddoris, Director of Quality, A. O. Smith Corp.
Panel Secretary:
L. O. Laabs, Chief Inspector, Le Roi Co.
Panel Members:
E. Schiesll, Technical Director, Mattatuck Mfg. Co.
N. Langill, Chief Inspector, Deere Mfg. Co.
F. Holbik, Quality Engineer, J. I. Case Co.
Ralph Brown, Chief of Quality Control, Minneapolis-Moline Co.

FORGINGS . . . What the User and Buyer Want to Know About Them

- What factors affect forging tolerances?
- Can a forging lower your costs?
- What new forging applications are there?
- How can buyer and vendor help control forging quality?

Panel Leader:
C. E. Stone, President, Interstate Drop Forge Co.
Panel Secretary:
H. Winkleman, The Ladish Co.
Panel Members:
H. F. Wood, Vice-President, Wyman-Gordon Co.
J. Dierbeck, International Harvester Co.
C. Olson, Works Manager, Unit Drop Forge Division of Fuller Mfg. Co.
H. Tillson, Estimating Engineer, The Ladish Co.

Welding . . . Tips on How to Overcome Various Problems

Discussion will cover problems in:
- Production welding on tractors and earth moving equipment
- Hard surfacing
- Use of low hydrogen electrodes
- Resistance welding of cast-iron parts in production
- Service welding

Panel Leader:
J. J. Chyle, Director of Welding Research, A. O. Smith Corp.
Panel Secretary:
Q. Ingerson, Metallurgist, Ampco Metal, Inc.
Panel Members:
I. R. Bartter, President, Automatic Welding Co.
M. Hippe, Sales Representative, Linde Air Products Co., Division, Union Carbide and Carbon Corp.
Carl Zilch, Chief Metallurgist, Bucyrus-Erie Co.
Peter Stern, Welding Engineer, Heil Co.
Willard Schumbacker, Welding Engineer, Allis-Chalmers Mfg. Co.
J. Franzreb, Metallurgist, J. D. Adams Co.

***GEARS . . . How to Make Them Trouble-Free in Service**

Producing gears that perform well in the field calls for:
- Careful attention to materials specifications
- Getting the most out of heat-treating methods
- Attention to gear fabricating techniques and equipment
- Steps to reduce gear noise

Panel Leader:
E. D. Hunt, Chief Metallurgist, Massey-Harris Co., Inc.
Panel Secretary:
E. J. Borisch, Mfg. Engineer, Milwaukee Gear Co.
Panel Members:
F. H. Boor, Engineer, Wisconsin Axle Division, Timken-Detroit Axle Co.
D. Hanson, Engineer, Massey-Harris Co., Inc.
G. C. Collins, Chief Engineer, Gear Division, Clark Equipment Co.
C. Tohn, Gear Technician, Caterpillar Tractor Co.

PRODUCTION CONTROL . . . Evaluating the Production Management Function

What steps should be taken to control:
- Raw materials inventory
- Work in process and stock
- Materials handling in relation to production control
- Performance goals
- Machine loadings
- Scheduling and costs
- Achievement of satisfactory customer relationships through production control.

Panel Leader:
J. E. Adams, Director of Purchases and Planning, White Motor Co.
Panel Secretary:
W. Hoth, Production Engineer, Evinrude Motor Division, Outboard Marine and Mfg. Co.
Panel Members:
P. A. Miller, Vice President, Leece-Neville Co.
Roscoe Byers, Factory Manager, Chain Belt Co.
Harvey Taylor, Assistant Works Manager, Heil Co.
Del Hanson, Assistant Factory Manager, J. I. Case Co.
L. Schmidt, Assistant to Vice President, Mfg., Tractor Division, Allis-Chalmers Mfg. Co.

***HEAT TREATING . . . Getting the Bugs Out of Heat-Treating Processes**

Certain heat-treating problems are common to many plants. Each company has gone about solving them in its own way. The interchange of ideas at this session will bring out the best ways of:
- Controlling distortion
- Hot oil quenching
- Using austempering for parts subjected to impact
- Carbo-nitriding
- Treating heavy sections
- Treating non-ferrous materials

Panel Leader:
J. E. Schoen, Professor of Engineering, Marquette University
Panel Secretary:
L. Higgins, Metallurgical Engineer, The Ladish Co.
Panel Members:
G. B. Kiner, Works Metallurgist, International Harvester Co.
J. Byerstead, Manager of Heat Treating, Nordberg Mfg. Co.
V. Erickson, Chief Metallurgist, American Steel Treating Co.
J. F. Klement, Director of Research, Ampco Metal, Inc.
Dale Wright, Manager of Heat Treating, Caterpillar Tractor Co.
L. Croner, Works Manager, Marmon-Herrington Co.

MACHINE TOOLS AND TOOLING . . . What's New in Metal Cutting

Production men are constantly on the search for ways to cut metal-cutting costs. To be discussed here are some of the things they are doing today and planning for tomorrow toward this end, such as:
- Ways of prolonging tool life
- Tool control methods
- New type coolants
- Factors determining basic tooling policies
- New machining techniques
- Proper machine tool maintenance

Panel Leader:
G. Swardenski, Factory Manager, Caterpillar Tractor Co.
Panel Secretary:
D. Hopkinson, Tool Engineer, Evinrude Motors Division, Outboard Marine and Mfg. Co.
Panel Members:
A. Tank, Master Mechanic, Heil Co.
R. Niels, Production Engineer, Allison Division, GMC
F. Sills, Superintendent, Haynes Steelite Co., Division, Union Carbide and Carbon Corp.
K. A. Powell, Mfg. Research Engineer, Minneapolis-Moline Co.
S. Mezzio, Tool Engineer, Blackhawk Mfg. Co.
T. Vickers, Master Mechanic, Clark Equipment Co.

* The Gear and Heat Treating panels will meet separately in the morning and will meet jointly in the afternoon to discuss problems common to both panels.

TECHNICAL SESSIONS

Tuesday, Sept. 15

8:30 a.m. **Ballroom**

Welcome to Milwaukee—**C. L. Spexarth,** Chairman, SAE Milwaukee Section

Chairman—**D. K. Heiple,** R. G. LeTourneau, Inc.

Secretary—**R. M. Smith,** Caterpillar Tractor Co.

Larger Equipment Needed for Open-Pit Mining
E. R. Dickie, Bagdad Copper Corp.
Open-pit mining and other off-the-road applications have created demands for larger and more efficient tractors and equipment. Actual mining experience measures the practical limits of bigness.

A Super-Regenerative Transmission for Multi-Driven Wheeled Tractors
G. R. G. Gates, Gates and Hardy Ltd.
Development of a new super-regenerative transmission combines the crawler's marvelous pull/weight ratio with the wheeled vehicle's go-anywhere-at-speed capability. Certain problems await solution.

(Sponsored by Construction and Industrial Machinery Subcommittee)

1:30 p.m. **Ballroom**

Chairman—**A. F. Meyer, Jr.,** Heil Co.

Secretary—**J. E. Wieschel,** Heil Co.

Development and Application of Oil Coolers for Torque Converters on Industrial Equipment
G. W. Gerstung, and **R. P. McDonough,** Harrison Radiator Division, GMC
Small, light packaged units are applicable to transmissions of mobile equipment. Large-capacity oil-to-air coolers serve air-cooled installations. Oil-to-water coolers function when radiator capacity is adequate.

Accelerated Testing of Tractor Components
D. R. Richardson and **G. R. Fuller,** Caterpillar Tractor Co.
Quick solutions for design problems derive from accelerated tests. However, testing isn't enough. Needed is comparative evaluation with results of normal use, service tests, field experience, and customer usages.

(Sponsored by Construction and Industrial Machinery Subcommittee)

Wednesday, Sept. 16

9:30 a.m. **Ballroom**

Chairman—**W. H. Worthington,** John Deere Waterloo Tractor Works

Secretary—**R. W. Hautzenroeder,** Harry Ferguson, Inc.

Report of the Tractor and Implement Safety Lighting Program
B. G. Van Zee, Minneapolis-Moline Co.
Field tests of lamps and reflectors have led to SAE Technical Board approval of the breakaway connector, now used by many manufacturers. Currently undergoing development are standard lamp-mounting brackets for tractors and implements.

"Crawler" Purview in Agriculture
R. O. McSherry, The Oliver Corp.
Practical farming operations repeatedly demonstrate need for both wheeled and crawler tractors. This paper outlines the crawler's future in the light of broadening agricultural developments.

Tractor Testing at Nebraska
L. F. Larsen and **C. W. Smith,** University of Nebraska
Nearly 500 pioneering field tests of tractors, covering belt hp, drawbar hp, drawbar pull, and fuel consumption suggest current need for makers and users to collaborate on design details, standardized dimensions—and more comprehensive tests.

(Sponsored by Tractor and Farm Machinery Subcommittee)

1:30 p.m. **Ballroom**

Chairman—**S. C. Heth,** J. I. Case Co.

Secretary—**Shirley Lake,** J. I. Case Co.

Universal Joint Applications to Power Take-Off Drives on Farm Machinery
F. M. Potgieter, Mechanics Universal Joint Division, Borg-Warner Corp.
Tractor output and farm-implement power requirements have been making unrelated, confusing growth. Here is a tabulation for design engineers of published information on power requirements, stress estimates, and results of torque meter tests.

(Sponsored by Implement Subcommittee)

Tillage Tools—Material and Heat Treatment
W. D. McMillan, and **W. C. Bliesener,** International Harvester Co.
Whether man eats, and eats well, depends primarily upon proper soil preparation, plus later cultivation and weeding. Plows, discs, blades, and harrows play their part. So also does steel, which must meet many requirements.

(Sponsored by Engineering Materials Activity and Implement Subcommittee)

Thursday, Sept. 17

9:30 a.m. **Ballroom**

Chairman—**K. W. Anderson,** Deere and Co.

Secretary—**C. L. Zink,** Deere and Co.

Tractor Hitches and Hydraulic Systems—An Implement Designer's Viewpoint
B. B. Johannsen, John Deere Plow Works, Deere and Co.
Whatever the outcome of the controversy over integral vs. drawn implements, hitches and hydraulic systems still must serve modern needs. And whatever the equipment, it should operate successfully with different tractor makes and models.

Prepared discussion by:
W. E. Knapp, Minneapolis-Moline Co.
E. W. Tanquary, International Harvester Co.
S. C. Heth, J. I. Case Co.
E. W. Todd, Massey-Harris Co.
L. G. Kopp, The Oliver Corp.

(Sponsored by Implement Subcommittee)

1:30 p.m. **Ballroom**

Chairman—**W. E. Swenson,** Minneapolis-Moline Co.

Secretary—**A. C. Cragg,** Donaldson Co.

Tractor Hitches and Hydraulic Systems—A Tractor Designer's Viewpoint
H. L. Brock, Ford Motor Co.
The influence of hitches and hydraulic controls upon tractor design represents a case of the utilitarian tail wagging the engineering dog. Design concept of these components actually can dictate tractor size and configuration!

Prepared discussion by:
Igor Kamlukin, Allis-Chalmers Manufacturing Co.
G. M. Eveleth, J. I. Case Co.
Thomas Evans, Minneapolis-Moline Co.
C. A. Hubert, International Harvester Co.

(Sponsored by Farm Tractor and Machinery Subcommittee)

7:00 p.m. **Ballroom**

DINNER

C. T. O'Harrow, Chairman

E. F. Tomlinson, Toastmaster

Robert Cass, SAE President

Principal Speaker to be announced

About

J. CARLTON WARD, JR. has been elected president of The Vitro Mfg. Co., Vitro Corp. of America, and Vitro Chemical Co. He has also been made a director of the companies. Ward directed development of the "Flying Boxcar" for the Air Force when at Fairchild Engine and Airplane Corp. He also founded and headed the project of Nuclear Energy for the Propulsion of Aircraft, a cooperative association of ten outstanding American companies, for the Air Force and Atomic Energy Commission.

JOHN T. BROWN has been elected president of J. I. Case Co., Racine, Wis. Brown, who became vice-president in charge of production in 1948 and executive vice-president in 1952, is a director of the Case Co., the Sivyer Steel Co., Milwaukee, Lyons Metal Products Co., Inc., Aurora, Ill., National Association of Manufacturers and the Wisconsin Telephone Co., Milwaukee.

H. WADE BARTH has been named chief engineer in the Cleveland Diesel Engine Division, GMC. He was chief engineer in the Electromotive Division, GMC, La Grange, Ill.

BRUCE W. KLEIN has been named chief engineer of the automotive products section for the Marshall-Eclipse Division, Bendix Aviation Corp., Troy, N. Y. Klein joined Marshall-Eclipse in 1948 after 13 years with GMC's Pontiac Division, and was appointed assistant chief engineer in 1949.

PHILLIP R. HEIM has been elected to the board of directors of Vard Inc., Pasadena, Calif., and appointed vice-president in charge of manufacturing. He was works manager at Vard.

FRANK B. DOYLE, former director of research, Guardite Corp., Chicago, will spend the remainder of '53 "at ease." Doyle, not now connected with any company organization, has returned to Raymond, Ill., his boyhood home. He began engineering by doing development work on a fuel injection system for Ingersoll-Rand Co.'s first diesel-electric locomotive in 1923, and finished with the design and development of equipment for explosive decompression in an altitude chamber in 1953.

DONALD E. FLINN who was manager of contractural engineering for United Aircraft Products, Inc., Dayton, is now field engineer at Aero Engineering, Inc., Indianapolis.

MILES LIVINGSTON BRUBACHER is automotive engineer for Ernie McAfee Engineering Co., Hollywood, Calif. He was automotive engineer in Dhahran, Saudi Arabia, for the Arabian American Oil Co.

FRANK M. ALLEN has been named senior layout man for the Chevrolet Central Office Division, GMC, Detroit. He was project engineer for the Cleveland Diesel Engine Division, GMC.

IRVING EARL SCHAUMBERG who was branch manager and technical instructor for the Sun Electric Corp., Chicago, is service instructor at the Product Service Laboratory, General Motors Institute, Flint, Mich.

C. L. LAWRENCE has been appointed district sales supervisor for The Permold Co., Medina, Ohio, and is in charge of the states of Michigan, Indiana, Illinois, Wisconsin and Iowa. He was sales engineer.

A. E. WILLIAMS has been elected vice-president in charge of engineering of Fruehauf Trailer Co., Detroit. Williams was chief engineer. He has headed staff development of numerous new commercial trailers and has also headed several projects for the development and design of a number of trailers being used in the armed forces.

CLARENCE F. FURST, formerly a chassis designer for the Hudson Motor Car Co., Detroit, is an engineer, design group, for Sverdrup & Parcel, Inc. in Tullahoma, Tenn.

FRED M. WINN, JR., who was in the U. S. Navy is now with Dowell, Inc., Tulsa, as a development engineer.

JOHN H. STICKNEY has been appointed sales engineer for the Northern Indiana and Central East Illinois areas for the Parker Appliance Co., Cleveland. Prior to joining Parker he was an administrative assistant for the Holley Carburetor Co., Detroit.

Members

LOUIS KRESSE BURNS, formerly chief engineer for the Winslow Engineering Co., Oakland, Calif., is now supervisor of the Engineering Division, Navy Bureau of Aeronautics, Corpus Christi.

HAROLD WILLIAM REESE is an instructor in the mechanical engineering department of the General Motors Institute, Flint, Mich. Previously he was a junior engineer in the experimental department of the Pontiac Motor Division of GMC.

C. KENNETH HUNT is now with the Albany, N. Y., branch of the White Motor Co. He was with the Gulf Oil Corp., Albany, N. Y., as automotive engineer.

EDGAR I. BILLINGS, sales engineer for the Socony-Vacuum Oil Co., Albany, N. Y., will retire from business this summer.

C. A. CHAYNE, in charge of GMC's engineering staff and a vice-president of GMC, was a conference chairman for the General Motors engineering educators' conference held in Detroit last July. Chayne and **CHARLES L. McCUEN** were two of six vice-presidents who gave talks about basic engineering and manufacturing policies and procedures.

SAE members who were guests included: Associate Professor Jay A. Bolt, University of Michigan; Professor George B. Du Bois, Cornell University; Associate Professor Edwin W. Niemi, Michigan College of Mining and Technology; Professor Paul M. Stafford, South Dakota School of Mines and Technology; Professor Karl W. Stinson, Ohio State University.

VIRGIL H. JOHNSON is now a member of the engineering department, Caterpillar Tractor Co., Peoria. Johnson was a member of the faculty, University of Minnesota, St. Paul.

EDWARD F. OBERT, professor of mechanical engineering at Northwestern University, received the eighth annual George Westinghouse Award in engineering education at a banquet of the American Society for Engineering Education, at the University of Florida, Gainesville, June 25.

DAVID C. PETERSON, director of engineering and manufacturing has been named to fill one of the six newly created vice presidencies at the Stewart-Warner Corp., Chicago.

M. A. CLEMENTS, general service manager for Caterpillar Tractor Corp., Peoria, has been named manager of parts at Caterpillar's new Peoria plant which will operate as a separate unit similar to the company's other plants.

GEORGE E. BERINGER has been appointed general factory-manager of the Aircraft Section, Bendix Products Division, Bendix Aviation Corp., South Bend, Indiana. With Bendix since 1936, Beringer has been factory-manager since 1951.

HENRY McKEEN, a member of the sales department of Campbell, Wyant and Cannon Foundry Co., has been named sales manager. Formerly McKeen was with the sales department of National Tube Division of United States Steel Corp. in Pittsburgh and Detroit.

FREDERICK W. WINYARD is now manager at the Brooke Dockyard & Engineering Works, Kuching, Sarawak, British Borneo. Previously he was proprietor of F. W. Winyard & Co., Ltd., Hong Kong, China.

HOWARD PIKE, chief engineer for National Airlines, Miami, will act as general chairman of the third Transport Aircraft Hydraulic Conference this fall in Detroit. The conference will be sponsored by Vickers, Inc., Detroit, and will be held at the Park Shelton Hotel, Nov. 3rd and 4th.

CARSON M. WALLACE is now in charge of all automotive sales offices in Philadelphia, Detroit and Gary for the Budd Co., Charlevoix, Mich.

JOSEPH C. SHENSTONE, formerly laboratory supervisor for Eaton Mfg. Co., Detroit, is now with the Ford Motor Co. as assistant engineer in the technical services department, Livonia, Mich.

SAE Father and Son

WILLIAM K. CRESON, (right) v.-p. of engineering, Ross Gear & Tool Co., and his son, **WILLIAM T. CRESON**, now doing graduate work at the Wharton School, University of Pennsylvania. Young Bill was a member of the SAE Student Branch at Purdue before graduating in 1950.

VICTOR A. OLSEN has become an executive consultant to Hupp Corp., Detroit. He will act in the same capacity for Amgears, Inc., Hupp's subsidiary which has operating plants in Detroit and Chicago.

FREDERIC C. MELDOLA is now with the White Motor Co. in Ohio as assistant chassis engineer. He was with the Mack Mfg. Corp., Allentown, Pa., as automotive engineer.

LEWIS K. SILLCOX was elected honorary vice-chairman of The New York Air Brake Co. and will continue as a director. He became executive vice-president in 1949 and vice-chairman in 1952. He has served as a director since 1948.

CHARLES T. ZAORAL, vice-president in charge of operations and a director of The New York Air Brake Co., was elected a member of the executive committee. He joined the company in 1952 after many years in an executive capacity with the Bendix Aviation Corp. and GMC.

H. LESLIE CASSELMAN who was with Reo Motors, Inc., Lansing, Mich., is now with Continental Motors Corp., Muskegon, Mich., as engineer of transportation engines.

EDWARD WARNER has been re-elected president of the Council of the International Civil Aviation Organization for a term of three years. Warner was a president of the SAE in 1930 and is a life member of the Society.

LEROY R. GRUMMAN, board-chairman of Grumman Aircraft Engineering Corp., Bethpage, N. Y., has given $110,000 to Cornell University. The money will be used for a building to house squash courts.

PAUL G. HOFFMAN, chairman of the board, Studebaker Corp., was chief speaker at the American Independence Day Festival, July 4, in Rebild National Park near Allenborg, Denmark.

WILLIAM CRAMPTON BECKER is a junior engineer "B", flight test operations and analysis, for Boeing Airplane Co., Seattle. Previously Becker was a first lieutenant in the U. S. Air Force.

HARRY P. BEAN, formerly an assistant section engineer for the Gulf Research and Development Co., Pittsburgh, is now measurement engineer for the El Paso Natural Gas Co.

ROBERT P. ERNEST has been named assistant section supervisor of the research engine section, Ford Motor Co., Dearborn, Mich. Ernest was previously a research engineer, senior, in the same section.

HAROLD AUGUST GRENERT is now superintendent of equipment for the Cincinnati, Newport & Covington Railway Co., Newport, Ky. He was superintendent of equipment for Bluebird Bus Lines, Lyons, Ill.

R. BRUCE HOPKINS is now graduate research assistant with the Department of Agricultural Engineering, Michigan State College. Hopkins was previously an assistant agricultural engineer at the University of Maine.

CARROLL D. FRUTH is now with the Lockheed Aircraft Corp., Georgia Division, as a flight test engineer. His previous position was flight test engineer for the Allison Division, GMC, Indianapolis.

WILLIAM E. BAKER, who has been engine liaison engineer for the GMC Overseas Operations Division, Detroit, is now engine engineer.

EUGENE L. BRICKMAN, employed by North American Aviation, Inc., Los Angeles, is now a research engineer "B". He was a research analyst "A".

DR. CHARLES LIPSON, Consultant, has moved his offices from Detroit to 2009 Shadford Road, Ann Arbor, Mich.

JOHN GITZ, has been appointed general manager of Republic Aviation's subsidiary at Lugano, Switzerland. The subsidiary will furnish spare parts for Republic Thunderjet and Thunderstreak fighter-bombers now serving the member nations of NATO. Gitz has been director of the foreign license program, Republic Aviation Corp., Farmingdale, N. Y.

WILLIAM SWALLOW has been appointed managing director of General Motors, Ltd., Dunstable, Bedfordshire, England. Swallow was director of the AC-Sphinx Spark Plug Co., division of General Motors, Ltd.

NORMAN G. SHIDLE, editor of SAE Journal, talked at the Business-Industry-English Institute at Purdue University on June 4. His topic: "Getting Written Ideas into People's Minds." The Institute was held under the auspices of the College English Association.

RAYMOND P. KOSTER is now a design engineer for Tokheim Oil Tank & Pump Co., Fort Wayne. Previously Koster was experimental axle engineer for Salisbury Axle Works, Division of Dana Corp., Fort Wayne.

MAX DACH has joined the Puerto Rico Transportation Authority at San Juan as general supervisor of maintenance, Bus Division. He was formerly superintendent of maintenance, Western region, for the Associated Transport, Inc., New York.

S. R. ZIMMERMAN, JR., has been elected a director of Raybestos-Manhattan, Inc., in Passaic. In January of this year he was appointed assistant general manager of the United States Asbestos Division.

EDMUND T. PRICE, president and general manager of Solar Aircraft Co., San Diego, was keynote speaker at the national convention of the National Association of Cost Accountants in Los Angeles, June 16.

G. P. FENN, who has been manager of the Sales Development Division, Caterpillar Tractor Co., Peoria, will apply his extensive general experience with Caterpillar to an expanded program with manufacturer-customers in the petroleum industry.

E. L. JONES, JR., previously district manager of Mid-States Freight Lines, Inc., Norwalk, Ohio, is now with the Service Trucking Co., Inc., Federalsburg, Md., as director of maintenance.

DONALD P. HEATH, formerly a chief in the Petroleum Administration for Defense, Aviation Fuels Branch, Refining Division, District of Columbia, is a research associate for the research and development department at Socony Vacuum Oil Co., Inc., Pitnam, N. J.

CHARLES E. HIRSCH is now technical engineer for the General Electric Co. in Cincinnati. He was a staff assistant in Richland, Wash.

HENRY THOMAS LORNE is now sales engineer in the New York office of The Fluor Corp., Ltd. He was technical representative for the Anglo-Iranian Oil Co., Ltd., in New York City.

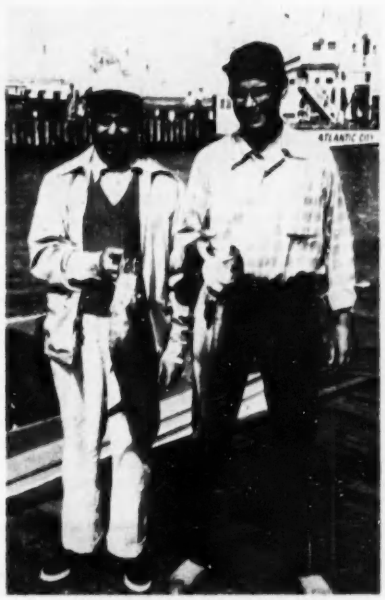
AUDRON DOUGLAS UPDYKE has become product engineer for the Sperry Farragut Corp., Bristol, Tenn. Prior to this he was a development test engineer for International Harvester Co., Motor Truck Engineering Dept. at Fort Wayne.

WILLIAM W. WATSON is now with Sverdrup & Parcel, Inc., Operating Division, Tullahoma, Tenn., as manager of the transportation branch. He was superintendent of the automotive and heavy engineering equipment department, ARO, Inc., in Tullahoma.

PETER P. GUARNER, formerly sales engineer for Henry Spen & Co., Inc., Brooklyn, N. Y., is now sales engineer for Couse Mfg. Co., Inc., Fifth Ave., N. Y.

PRENTISS C. NELSON is now with the Aramco Overseas Co., The Hague, Netherlands. Previously he was an engineer for the Arabian-American Oil Co., New York City.

ALAN B. GORMAN, manager of the Automotive Division of Esso Standard Oil Co., New York, was honored on his 30th anniversary with the company. Gorman was presented a service emblem with two diamonds. He is president of the National Council of Private Motor Truck Owners and chairman of the Central Committee on Automotive Transportation, American Petroleum Institute. He has also written many articles on the value of truck transportation.



AL HAYNES (left) and **JOE MACK** (right) hooked the largest fish caught off Atlantic City this year, a 3 lb 11 oz Bonita and a 6 lb 11 oz Blue Fish, during the SAE Summer Meeting. Haynes, section supervisor of research engineering for Ford Motor Co., Dearborn, Mich., and Mack, field engineer for Timken Roller Bearing Co., Detroit, were entered in Capt. Starns' fishermen's contest.

Honorary Degree to Critchfield

ROBERT M. CRITCHFIELD (right) was awarded the honorary Doctor of Laws degree by Franklin College, Franklin, Indiana, on June 7. He is a vice-president of GMC and general-manager of the Pontiac Motor Division.

Critchfield received his degree from President Harold W. Richardson (left) who hailed him as "a successful businessman and creative engineer who has given freely of his talents to social and education advancement." Mrs. Critchfield was with her husband at the presentation of the degree.

Foreign Products for U. S.

Courtesy of "Business Week"

WILLIAM R. ENYART, president of Simmonds Aerocessories, Inc., Tarrytown, N. Y., has recently gone to Europe. He is looking for foreign inventions suitable for U.S. markets. Enyart will screen precision products, chiefly in the aircraft line, which may be successful in America. He has been a military and private flier, editor, and member of various societies and aviation boards.

W. P. TURNER has been transferred to Charlotte, N. C., as a zone service manager for the Chevrolet Motor Division, GMC. Turner was regional service engineer for Chevrolet at Atlanta, Ga.

GENE A. CORMANY is with the Zollner Machine Works, Fort Wayne, Indiana, as an engineer. He was previously with Perfect Circle Corp., Hagerstown, Ind., as an engineer.

ROBERT CHARLES LEDERER, previously a sales engineer in the Philadelphia office of Bendix-Westinghouse Automotive Air Brake Co., Elyria, Ohio, is now division engineer, Pacific Division, for the same company, located at Berkeley, Calif.

CAPT. EDWARD V. RICKENBACKER, Eastern Airlines' president, is New York State committee chairman directing state activities for the 50th Anniversary of Powered Flight.

SAE members serving with him on the committee are: **RALPH DAMON,** president Trans World Airlines, Inc., New York City; **LEROY GRUMMAN,** board-chairman Grumman Aircraft Engineering Corp., Bethpage; **C. F. B. ROTH,** president Air Cooled Motors, Syracuse; **E. G. HAVEN,** manager of General Electric Co.'s Aviation Division, Schenectady; **THEODORE P. WRIGHT,** vice-president for research, Cornell Aeronautical Laboratory, Inc., Buffalo.

PAUL S. BAKER who was engineering manager for Chance Vought Aircraft, Dallas, is now with Republic Aviation Co., Farmingdale, N. Y., as development engineer.

VINCENT C. GILBERT is with the Food Machinery & Chemical Corp., San Jose, Calif., as a design engineer. He was design and test engineer in the Cadillac tank plant, GMC, Cleveland.

LT. COL. M. A. KINLEY, Dallas, has been named commandant of the Eighth Army Ordnance School, at Yongdung-po, suburb of Seoul. During World War II Kinley was an inspector general dealing with maintenance problems, and in '46 returned to work interrupted by the war as fleet engineer for Ethyl Corp.

STANISLAS MAKOWIECKI, is now with the Aeronautica Industrial, S. A., in Madrid as director of the New Projects Section, the Carabanchel Alto Factory. Previously he was chief engineer in the aeronautics department, Iberavia, S. A., in Madrid.

GORDON R. STONE, formerly assistant professor of mechanical engineering at Wayne University, Detroit, is now with the State Department's Voice of America, Munich Radio Center, as power plant supervisor.

C. C. KENLAN, president of Kenlan Engineering Co., has changed his address from Lancaster Ave. & Morris Rd., Wynnewood, Pa., to 122-124 West New York St., Indianapolis.

ERNEST R. CUNNINGHAM, JR., is now in the engineering department of the Frank G. Hough Co., Libertyville, Ill. He was with the Lavers Engineering Co., Chicago, as a design engineer.

EDWARD ROBERT HUPERT, formerly manager of engineering, processing, and designing for Ford Motor Co., Cleveland, has been named manager of the catapult project for E. W. Bliss Co., Canton, Ohio.

WILLIAM M. FRANK, previously sales manager for Johnson Products, Inc., Muskegon, Mich., has been named vice-president of sales and advertising.

FORD W. SPIKERMAN who was assistant service manager for the Cleveland tank plant of Cadillac Motor Car Division, GMC, is now general supervisor of service training activities.

WALDO H. KLIEVER is now vice-president and director of instrument development for Clevite-Brush Development Co., Cleveland. Kliever was previously director of research for Minneapolis-Honeywell Regulator Co., Minneapolis.

S. C. MASSARI has become general manager of the Foundry Division of Hansell-Elcock Co., Chicago. Massari was technical director of the American Foundrymen's Society.

W. E. WHITE is now product engineer with the Clark Equipment Co., Buchanan, Mich. White was formerly an engineer for Bendix Products Division, Bendix Aviation Corp., South Bend, Indiana.

RICHARD KOEGLER has been elected president of the Technical Societies Council of the Niagara Frontier. Koegler is project engineer in the flight research department at the Cornell Aeronautical Laboratory, Inc., Buffalo.

PHILIP E. B. VAILE has been appointed supervisor of the mechanical testing laboratory of The Vacuum Oil Co., Ltd., Coryton, Stanford-le-Hope, Essex, England. Vaile was previously assistant to the director of engineering of Anglamol, Ltd., "The Knowle," Hazelwood, Derbyshire, England.

ERNEST V. SMUTEK has rejoined Hupp Corp., Detroit, as sales engineer for the Huppower and Globe Stamping Divisions. Smutek was sales engineer for Anderson Co., Detroit.

G. SCOTT SAMPLE, formerly with Redmond Co., Inc., has joined Hupp Corp. as sales engineer for the Huppower and Globe Stamping Divisions.

Piasecki, Berlin Get Honor Degrees

Frank N. Piasecki

Don R. Berlin

FRANK N. PIASECKI, chairman of the board of Piasecki Helicopter Corp., Morton, Pa., and **DON R. BERLIN**, president of the company, have been awarded honorary degrees.

Piasecki, who received the honorary Doctor of Aeronautical Science degree from Pennsylvania Military College, Chester, was cited for his accomplishments in the helicopter field and their future promise. He will return this month from a six-week tour and study of European helicopter developments.

Berlin received the honorary Doctor of Engineering from Purdue. He has spent more than 30 years in the aircraft industry, working for the Army Air Corps, Douglas Aircraft, United Aircraft, Curtiss-Wright, and McDonnell Aircraft.

RAY F. WILKIE is proof director in the Automotive Division, development and proof services, Aberdeen Proving Ground, Md. Previously Wilkie was application engineer in the tractor division of Allis-Chalmers Mfg. Co., Milwaukee.

JOSEPH W. WECHSLER, formerly assistant engineer, is now an assistant group leader for the Rand Corp., Santa Monica, Calif.

EMERSON D. F. OGLE who is with SKF Industries, Inc., is now assistant sales manager in Philadelphia. Previously he was assistant district manager in the Cincinnati office.

JOHN A. WATKINS is factory manager for the Moore Co., Marceline, Mo. Watkins was previously general manager of Sterling Engineering & Mfg. Co., Wilkes-Barre, Pa.

LT. COL. SIDNEY G. HARRIS who was a director of material at Wolters Air Force Base, Mineral Wells, Texas, is now a student in the logistics staff course, Air Command Co. Staff School, Montgomery, Ala. He is a past chairman of the SAE Metropolitan Section.

PROFESSORS EARLE BUCKINGHAM and **JOHN M. LESSELLS**, both of the mechanical engineering department, M.I.T., will retire this summer after long service. Buckingham joined the department in 1925. He will continue next fall as emeritus professor of mechanical engineering and as lecturer in the department. Lessells, with M.I.T.'s faculty since 1936, also will be with the department as emeritus associate professor and part-time lecturer.

A. S. LEONARD is now president of Cummins Rio Grande Sales and Service, Inc., which has been organized to handle former Albuquerque, New Mexico and El Paso, Texas, operations of Cummins & Moran, Phoenix, Arizona. Leonard has been regional manager of the Southwest for Cummins Engine Co. for the past nine years.

Chrysler's "First Lady"

Lucille Pieti is the first woman automotive engineer to officially represent Chrysler and was the only woman in a Wayne University graduating class of 300 engineers. Miss Pieti is now traveling with Chrysler's "New Worlds in Motion" show, explaining to the public how the modern automobile is conceived, designed, and executed. She was enrolled in Chrysler Corp.'s cooperative student-training program.

Z. C. R. HANSEN, vice-president of the Diamond T Motor Car Co., Chicago, will be vice-chairman of the Program and Arrangements Committee for the 15th annual meeting of the National Council of Private Motor Truck Owners. Other SAE members who will serve on the committee are: SAE Vice-President O. A. Brouer, head of the General Automotive Division, Swift & Co., Chicago; M. E. Cowden, manager of the delivery department, Purity Bakeries Corp., Chicago; A. H. Kreuder, superintendent of motor transportation, Wilson & Co., Chicago; and H. O. Mathews, general manager of transportation and distribution, Armour & Co., Chicago.

HERMAN A. DOBSON has been named assistant to the general-manager of Industrial Stamping and Mfg. Co., Division of the Vinco Corp., Detroit. He will be general coordinator of the division's activities. With Vinco since 1941, Dobson has been supervisor of planning and scheduling for several years.

FREDERICK C. WEYBURNE, general-manager of Marshall-Eclipse Division, Bendix Aviation Corp., Troy, N. Y., has been elected president of the Friction Materials Standards Institute, Inc. **GEORGE E. RITTER**, vice-president and general-manager of the Molded Materials Division, Carlisle Corp., Ridgway, Pa., is the new vice-president of the Institute.

JOHN LEWIS DILWORTH, previously associate professor of mechanical engineering at the Pennsylvania State College, is now development engineer with the Paxton Engineering Co., division of McCulloch Motors Corp., Los Angeles.

E. A. MAGYAR, formerly with the Navy Dept., is sales engineer, Titeflex, Inc., Newark.

HAROLD N. BOGART, supervisor for the metallurgy unit in manufacturing research, Ford Motor Co., has a Sloan fellowship for executive development at M.I.T. and is on leave of absence from the Ford Co.

Students Enter Industry

CLARENCE W. KIRKPATRICK (University of Toronto '53) is now working with the Massey-Harris Co., Ltd., Toronto. Kirkpatrick was an honor graduate.

RICHARD L. McGOURTY (West Coast University) is in training for a computer field engineer position with the Computer Research Corp.

ROBERT C. MELLIN (Purdue '52) is now in the Armed Forces, Co. E, 25th Armored Engineering Battalion, Fort Leonard Wood, Mo.

CHARLES E. ROMEISER (Rensselaer Polytechnic Institute) is a design engineer for the Lennox Furnace Co., Syracuse.

CHARLES F. FROEBEL (Purdue University '52) is in the U. S. Army. Froebel is on leave of absence from the Harnischfeger Corp., Milwaukee, where he was a trainee engineer.

WILLIAM E. RUMSEY, JR., (West Coast University '53) is at the Douglas Aircraft Co., Calif., as a junior engineer "A".

LEWIS L. BROADBENT (Northrop Aeronautical Institute) is an engineering draftsman at Douglas Aircraft Co., Long Beach, Calif.

SAL FRANK ARTINO (Fenn College '52) is a trainee at the Cleveland Graphite Bronze Co., Cleveland, Ohio.

HARRY C. WALKER (Utah State & Northrop Aeronautical Institute) is with the Douglas Aircraft Co., Torrance, Calif., as a design draftsman.

DAVID C. GILDERSLEEVE (California Institute of Technology) is a junior engineering aid with the California Department of Public Works, Division of Highways, at Los Angeles.

RICHARD MARCO HECHT (Tri-State '53) is with Chance Vought Aircraft, Dallas, as a mechanical engineer.

ROBERT ANSON GAY (United States Naval Academy '52) is a second lieutenant in the U. S. Air Force. He is a student in jet training at the Williams Base, Chandler, Ariz.

IGNATIUS C. GREGG (Fenn College '52) has joined the Industrial Rayon Corp., Painesville, Ohio, as a plant project engineer.

ALAN B. CLARKE (Parks College '52) is a lieutenant in the U. S. Air Force. He is a student at the Lowry Air Force Base, Denver, Colo.

DONALD CLEAVINGER (California State Polytechnic College '52) will be transferred to the Goodyear Atomic Corp. as a junior engineer. He will receive training at various atomic energy plants until the Pike County project is constructed where he will be located.

ERVIN L. PENKALSKI (University of Wisconsin '52) is a field engineer with the GMC's AC Spark Plug Division, Milwaukee, Wis.

JAMES S. ALCORN (Northrop Aeronautic Institute) is a liaison engineer for Douglas Aircraft Co., El Segundo, Calif.

HARVEY F. HOHLFELDER, JR. (Fenn College '53) is with the F. Hohlfelder Co., Euclid, Ohio, as an assistant tool engineer.

HOWARD L. WHITE (Case Institute of Technology) is a development engineer trainee at the Euclid Road Machinery Co., Cleveland, Ohio.

JOHN R. HOFFMANN (Academy of Aeronautics '52) is now in the armed forces.

RALPH J. OPRE is a second lieutenant in the Durability Test Branch at Aberdeen Proving Ground, Aberdeen, Md.

GLENN D. PUSCH (Bradley University '52) is with the United States Rubber Co., Chicago, Ill., as an industrial engineer.

RONALD C. HARRIS (Michigan College of Mining & Technology '52) is now a second lieutenant in the U. S. Air Force. He is doing test engineering at the Wright-Patterson Air Force Base, Ohio.

Continued on Page 124

Obituaries

JAMES B. FISHER

James B. Fisher, consulting engineer for the Waukesha Motor Co., Waukesha, Wis., died April 8. He was 69.

Consultant since 1949, Fisher joined Waukesha Motor Co. as mechanical engineer in 1915. He was vice-president from 1935–1949 as well as director in charge of the engineering and research departments.

Prior to his association with Waukesha, Fisher entered industry with the American Steel Foundries Alliance, Ohio, then became shop-apprentice for the Alliance Machine Co. in 1904 and draftsman for the Federal Steel Co., Waukesha, 1909–1914.

A leader of various phases of SAE activities, Fisher was chairman of the committee which originated SAE viscosity numbers for lubricating oils. He did research on fuels and oils for use in internal-combustion engines with the SAE and American Petroleum Institute, and during World War II was a member of the War Advisory Committee, Ordnance Department.

Author of technical papers, "Factors Influencing the Design of Modern High-Speed Diesel Engines" and "Development of a Combustion Chamber for Medium and High-Speed Diesel Engines," which were presented before SAE, Fisher also was a member of many other organizations, including American Society for Testing Materials, American Petroleum Institute, American Society of Agricultural Engineers, and the Society of American Military Engineers.

LESTER J. HOWARD

Lester J. Howard, foreman of the shop for Guy F. Atkinson & Ostrander Co., Wenatchee, Wash., died May 31 in an auto accident. He was 38.

Howard was a native of West Point, Ill. and attended West Point schools. He had a great deal of experience working with automotive apparatus. At one time he was in charge of general maintenance of plantation equipment for Pioneer Mill Co., Ltd., Hawaii. Prior to that he had worked for Boeing Aircraft Co. and Winston Bros. Construction Co. During 1945 he owned and operated the Renton Automotive Co.

OTTO A. RADERMACHER

Otto A. Radermacher, died suddenly June 20. He was 59.

Radermacher was automotive advisor with the 94th Division of the U. S. Army during World War II. He instructed army personnel in operation and maintenance of motor vehicles.

Previously he was a superintendent of transportation for Interstate Baking Corp., Chicago, where he had full responsibility for the company's fleet of vehicles. He directed mechanical maintenance and was in charge of administrative methods, procedures and purchasing. He had also been supervisor of motor equipment for the Illinois Bell Telephone Co., Chicago.

Radermacher, who was born in Chicago and attended Englewood Tech. and Lane Tech., was associated with A-R Auto Parts Co., Paw Paw, Mich. at the time of his death.

F. MALCOLM REID

F. Malcolm Reid, vice-president and director of engineering for Fruehauf Trailer Co., Detroit, died May 11. He was 53.

Reid joined the Fruehauf Trailer Co. in 1923 as a designer and supervisor of the engineering department. Prior to that he did experimental automotive design work and laboratory testing for L. B. D. Engineers (not now existent) in Detroit.

He entered the automotive field as an apprentice draftsman for the Packard Motor Co. in 1916. In 1917 he did tool designing for the Cadillac Motor Co., and then in 1918 worked for the U. S. Government in the Aircraft Production Bureau.

STUART NIXON

Stuart Nixon, research engineer of Sealed Power Corp., Muskegon, Mich., died June 9 from a heart attack. He was 53.

Nixon graduated from the Massachusetts Institute of Technology in 1923 where he received a degree in mechanical engineering. He then joined Continental Motors Corp.

In 1934 he became associated with Sealed Power Corp. where he held several engineering positions during the past 18 years. He developed and patented many piston ring improvements which were assigned to Sealed Power.

He held membership in the American Society of Mechanical Engineers and the American Oil and Gas Society, as well as in SAE.

Nixon is survived by his wife and two children.

GIBBS BLACKSTOCK

Gibbs Blackstock, developer of automatic transmissions, died last March. He was 65.

A native of Toronto, Blackstock earned both B.A. and M.A. degrees from the University of Toronto where he received training in chemistry. He had also attended St. Andrew's College, Toronto, and later did research at Manchester and Oxford Universities, England.

He was head of a section of the research department at the Chance & Hunt Chemical Factory, Oldbury, England, from 1915 to 1918. Later, however, he thought of the possibility of a certain system of automatic change-gear device for motor cars and worked on the development of his invention.

DEAN ALVIN WALTERS

Dean Alvin Walters, technical service manager for Willys Motors, Inc., Toledo, died February 20. He was 63.

Practically all of Walters' automotive experience was with Willys. He began work with Willys in 1909 and was with them continuously until his death. He held positions in production, testing, research and field service. Later he became zone service manager and then national director of service.

An Ohio native, Walters was born in Youngstown. He was a student at Coitsville District High School, Youngstown, and La Salle Extension University, Chicago.

S. E. MURPHREE

S. E. Murphree, 54, died of coronary occlusion June 13. He was sales engineering representative for Continental Oil Co., Fort Worth.

Prior to joining the Continental Oil Co., Murphree was an instructor at Texas A & M College. He had also worked for several Houston companies, Schlumberger Well Surveying Corp., Brown & Roost Construction Co., Russ Mitchell Construction Co., and the Westark Construction Co. in Bay City, Texas.

Born in Salado, Texas, Murphree attended high school at Medicine Mound and later Grubbs Vocational College in Arlington, Texas, and Anderson Diesel School in Los Angeles, Calif.

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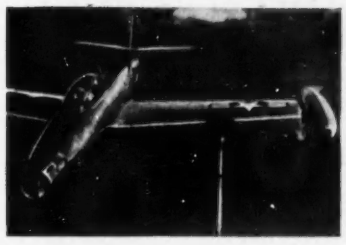

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Vice-chairman: **William B. Ribando**, experimental engineer, Lycoming-Spencer Division, Avco Mfg. Co.; treasurer: **Ewing W. Mueseler**, instructor, Williamsport Technical Institute; secretary: **Allen Weiss**, supervising agent, U. S. Department of Commerce, Civil Aeronautics Administration.

Continued from Page 89

the wear is of the corrosive type. The fuel was a "high deposit" type. It had a high sludge number and contained 50% or more of by-passed thermally cracked stock.

Jet Engine Fuels Need Further Research

Based on paper by

P. D. DORAN

Pratt & Whitney Aircraft

CLEAN fuel must be delivered to an engine at all times. This requires that fuels be carefully filtered. In jet fuels, particularly the heavier ones, hydrocarbons in the form of waxes which solidify or "cloud" at lower temperatures (but temperatures still well above the freeze point of the fuel) cause serious clogging of filters. Despite considerable research, there is no reliable test of the fuel filterability factor available at present. Even though fuels may meet the ASTM -76 F freeze point, they vary widely in this characteristic.

It is to be hoped that researchers will be successful in identifying the hydrocarbon elements responsible for filter clogging and in finding ways to rule them out of fuels by physical bench test requirement in the specification. Until this is done, special measures will have to be taken to handle fuel so that it will be delivered to the engine in proper condition and in adequate volume.

For satisfactory operation a fuel must not contain appreciable quantities of solid or resinous material, which requires that it does not deteriorate in storage. However, little is known regarding methods of evaluating storage stability in the kerosene fuel range. The inhibitors used with gasoline may function well in these fuels, but the test methods do not appear to be applicable.

One of the most troublesome leftovers from turbine fuel combustion is carbon which occurs in two principal forms. One form is amorphous carbon, a comparatively harmless one which can be handled by suitable engine design. This form of carbon is soft and fluffy and is formed generally under conditions of excess oxygen at low pressures and temperatures.

The second form—graphitic carbon—is the real trouble-maker. It is pure carbon, hard and crystalline in structure. It is a natural product of the breakdown of certain fuels during combustion and is inherent in such fuels. The heavier the fuel, the greater the problem presented by this carbon under existing fuel specifications.

We feel that the fuel manufacturer might help through the development of some scavenging agent or catalytic control similar to those being investigated to eliminate or minimize deposits of lead compounds in piston engines. Our work indicates that carbon deposition is effected more by the boiling point of aromatics than by their volume. Reasonably satisfactory experience has been obtained with fuels where the boiling point of aromatics was held down to 400 F. (Paper, "Some Considerations Regarding Fuels for Turbine-Powered Transports," was presented at SAE Annual Meeting, Detroit, Jan. 15, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

Adequate Roads Don't Cost, They Pay

Based on paper by

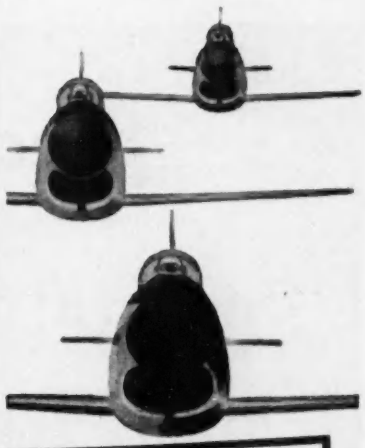
ARTHUR C. BUTLER

National Highway Users Conference

PROJECT Adequate Roads, widely known as P.A.R., was formed by representatives of wide and diverse interests who believe that road and street inadequacies have become more costly than we can afford. Poor roads compromise our defense effort and are a cost to our national life in terms of time, gasoline, and accidents. In short, adequate roads don't cost, they pay.

Basic to the P.A.R. charter is emphasis on improving highways according to priority of need. Other principles are: classification of roads into systems; funds for adequate highway systems; dedication of highway use taxes to highway purposes; fair distribution of highway costs; and better highway administration.

P.A.R. groups in the states are working right now on the matter of obtaining sufficient funds as well as furthering other P.A.R. principles. These state groups have great value because they can bridge over, with understanding, the gap which has too long existed between highway officials and the man in the street. They can study highway official programs and take their own recommendations to their individual groups. They can invite officials and the legislature to participate in discussions and make known to these parties their group feeling. They can encourage public interest in the highway problem and its solution. And finally, they can be the means for informing the man in the street about highway needs so that he can say what



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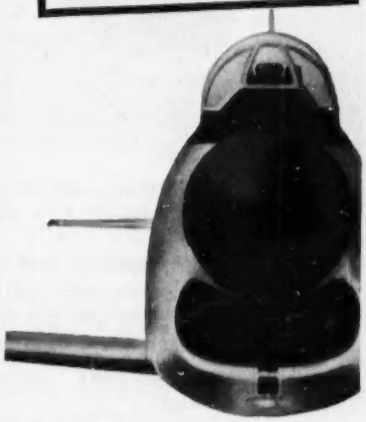

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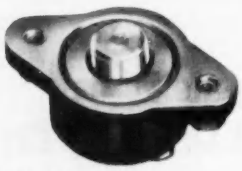

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he wants done with his tax dollar. (Paper "Adequate Roads Don't Cost, They Pay" was presented at SAE Metropolitan Section, New York, April 2, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

Why Compressed Air Wins as Power Source

Based on paper by

D. O. MEEK

Gardner Denver Co.

ECONOMY is the real reason for using compressed air in the construction industry. In its ability to transmit energy without losses, compressed air is less efficient than electricity, but on the job it may be more economical because of the labor factor.

Steam, electricity, gasoline, oil and compressed air have all been used for rock drilling. Air drills have the merit of being the lightest in weight and smallest in size. They minimize the hazard of fire and explosion. Furthermore, the air exhausted at the drill provides a source of fresh air up to the volume of 300 cfm which is a contribution of great importance under certain conditions. (Paper, "Why Compressed Air is Used for Construction Work," was presented at SAE Earthmoving Industry Conference, Peoria, Ill., April 8, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

Foreign Engines Hard to Americanize

Based on paper by

WILLIAM P. GWINN

Pratt & Whitney Aircraft

IF our naturalization restrictions on people were as complicated as the technical changes required to adapt foreign engines to U.S. production, the population of this country would probably still be mostly Indians. First comes translating blueprints and specifications into our technical language, then, for some mysterious reason, tolerances called for by the British specifications seem not to work out just right in an American plant.

In reproduction of the Rolls Royce Nene turbojet emphasis was put on changes in the fuel system and accessories. American requirements are

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very different and much more exacting. Generally, greater capacities are needed throughout and standbys are called for, notably in the fuel system. So great is the time and work required in adaptation that the effect is like adding new components which must be run through the mill of design, test, and development.

There is a difference in the systems used in England and America to rate the power of production engines. The British ratings were officially set at a certain figure, but a so-called "minus tolerance" of as much as 4% was allowed on individual engines. In other words, a jet engine actually delivering 4800 lb of thrust on production test would still qualify as a 5000 lb thrust engine. No minimum variation is permitted to American engines. To achieve a specified rating, an American engine must never go below that rating, which means that the actual range will be somewhat above it. (Paper, "The Jet Grows in Connecticut," was presented at SAE Southern New England Section, New Britain, Conn., Dec. 4, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

Tells Design Method For Automatic Controls

Based on paper by

AARON S. BOKSENBOM
and
RICHARD HOOD

Lewis Flight Propulsion Laboratory, National Advisory Committee for Aeronautics

This paper will appear in full in SAE Transactions

AN analysis, made at the NACA Lewis laboratory during the latter part of 1950, developed a rational method of control synthesis that starts from any arbitrary but physically realizable criterions and results in the equations for the best system that satisfies these criterions. The nature of the criterions, in general, requires minimizing certain time integrals by using the calculus of variations, and the methods developed are an application of the calculus of variations to the problem of control synthesis.

First, a careful scrutiny is made of the whole problem, followed by a development of general results. These results are then applied in examples to the design of turbojet engine control systems. In general, the methods used vary according to the order of the differential equation describing the plant, the process, or the system being controlled and according to the number of degrees of freedom or independent variables. Detailed analyses are pre-

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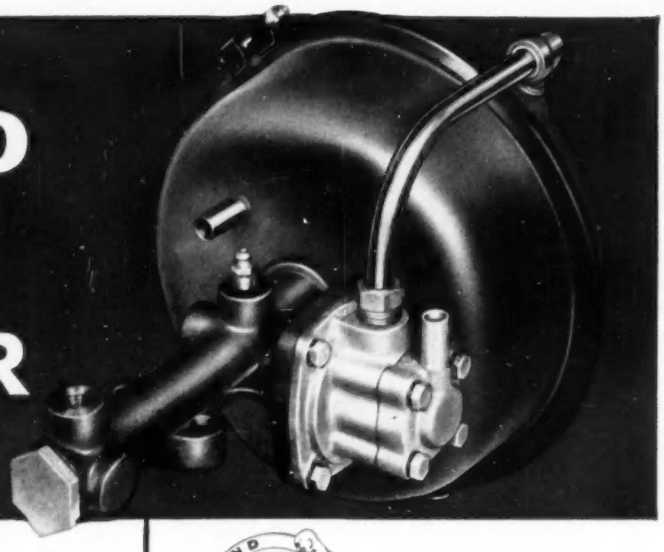

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sented for application to a system of first order and of one degree of freedom. General results for systems of second order and any number of degrees of freedom are developed in the appendix. (Paper "Automatic Control Systems Satisfying Certain General Criterions on Transient Behavior" was presented at SAE Annual Meeting, Detroit, Jan. 14, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

Correct Oil Choice Vital to Air Cleaners

Based on paper by

H. M. TURNER
Donaldson Co., Inc.

CHANGE in daily temperature has an important bearing on oil-bath air cleaner operation. When, for example, the kerosene and oil mixture is used and the engine starts to operate on a cold morning, there is an immediate passing off of kerosene light ends. If the day gets warm enough, a substantial portion of the kerosene is lost, with many detrimental effects. If enough kerosene passes away, a thicker oil will be left as required for the higher temperatures that follow, but the oil level will be low, resulting in lower efficiency and lower dust holding capacity, leading to more dust to the cleaner.

Assume again that there is a cooling down at night to -15 or -20 F. The morning start will be made with too viscous an oil. We have found in tests that use of some of the new oils is preferable. To meet temperatures of -15 to -30 F hydraulic oils are much to be preferred over the kerosene and oil mixture.

Summer and hot weather conditions must also be considered. Many current recommendations are based on past experience when we were not drawing terrific horsepowers out of small engine blocks. The ambient temperature around many units is not increased at all, but the heat of the fan blast has risen considerably, and the long hours of operation are increasing, with the result that many air cleaners operate today in temperatures of 140 to 170 F for long periods of time. Under such conditions use of low viscosity oils make a tremendous reduction in the air capacity safety factor. Here again, the problem of choosing the right oil is not easy. Very few operators would have heavier oils on hand, and even if they did, they would be reluctant to use them. Much better results can be obtained by placing the air cleaner and its inlet where it is not subjected to such high temperatures. (Paper "The Heavy Duty Air Cleaner Story Today" was presented at SAE Central Illinois Section, Peoria, Nov. 17, 1952. It is

ON LAND, SEA AND AIR

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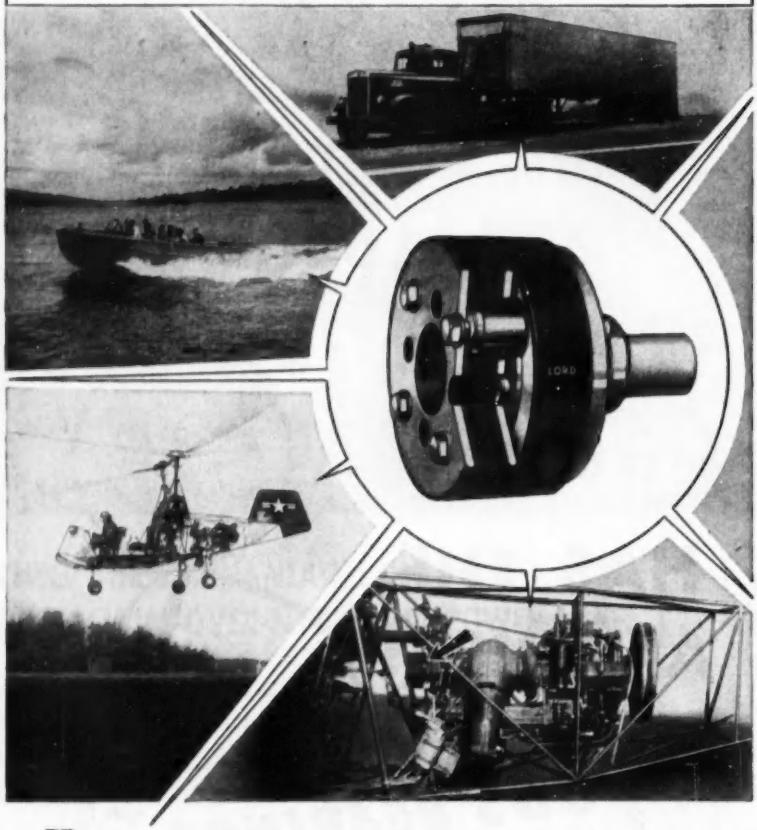

HERE again you see at a glance Lord versatility in designing bonded-rubber components for a wide diversity of machines. The photo at top right shows the Boeing Gas Turbine-Driven Truck-Trailer for heavy cargo hauling. At the top left you see a United States Navy personnel boat driven by the Boeing Gas Turbine Engine. Directly beneath is the Kaman Helicopter powered by the Boeing Gas Turbine Engine; details are clear in the foreground. The Lord Bonded-Rubber Flexible Coupling designed for the job transmits the power in each machine.

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How To Make Pistons Go To Work in 'Copters

Based on paper by

J. J. SHIELDS

and

J. T. BOWLING

Continental Aviation and Engineering Corp.

ADAPTING aircraft reciprocating engines to helicopters was not the simple job it was thought it might be. Many changes and additions had to be made to get light, compact, accessible, well-cooled powerplants that could meet the rugged performance schedule of helicopters.

It was found expedient, for example, to mount engines vertically or nearly vertically. This necessitated that (1) breathing facilities be rearranged, (2) oil seals made to operate under a head of oil, and (3) magnetos with impulse couplings — normally operated with gravity-actuated flyweights—be spring-loaded to operate with vertical shafts.

With weight a vital consideration in helicopters, every effort also had to be made to minimize or eliminate the flywheel as such. Where transmissions were mounted remotely from the engine crankcase, the cooling fan was employed as a flywheel to good advantage. With the transmission mounted on top of the crankcase, the portion of the clutch rigidly attached to the crankshaft was made to serve as the flywheel.

Engine cooling presented special problems, too. While fixed-wing aircraft make use of forward motion to move cooling air, helicopter cooling systems get no such assist. Axial flow fans, exhaust ejectors, or combination of both had to be used to impart motion to the cooling air. (Paper, "The Reciprocating Engine in the Helicopter," was presented at SAE Annual Meeting, Detroit, Jan. 14, 1953.)

Sufficiency Rating Key to Better Highways

Based on paper by

ROY E. JORGENSEN

National Highway Users Conference

OUR approach to the highway problem can be improved by more general adoption of some business practices which are readily adaptable to highway planning and programming. First, let's get an annual inventory established for each road and street system; follow it with a priority program-

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"THERMOIL-GRANODINE"® manganese-iron phosphate coatings provide wear-resistance (anti-galling, safe break-in of friction or rubbing parts) for friction surfaces such as pistons, piston rings, gears, cylinder lines, camshafts, tappets, crankshafts, rocker arms, etc.; and rust proofing for small arms, weapon components, hardware items, etc.

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ming procedure that is simple yet effective (both goals can be achieved with sufficiency ratings), and finally, let's get annual program reporting established as a regular and important highway department function.

The theory of sufficiency ratings is extremely simple. A completely adequate section of highway rates 100. Road sections having deficiencies of any kind in their structural make-up, their effectiveness in serving traffic, or their safety, are marked down from 100, according to formulas and procedures. The lower the rating, the poorer the road is. Ratings are reviewed annually to take account of changes in traffic and road conditions.

Rating procedures used by the states vary somewhat, but the basic approach is the same. The aim is to determine how and to what degree individual road and street sections stack up in comparison with truly adequate facilities.

After sufficiency ratings have been determined comes what is called a traffic adjustment. This is done to give weight to the traffic importance of the road section. Actually, each road is rated against standards appropriate for the traffic it serves. The end ratings are comparable; for example: a 70 basic rating on a 100 vehicle-a-day road is equal in its service for the 100 vehicles as a 70 rating road carrying 1000 vehicles a day.

Rating makes the worst road sections immediately evident and indicates how critical the inadequacy is. Interested individuals and groups, lacking familiarity with engineering, find that sufficiency ratings provide a simple, readily understood evaluation of the highway system.

Sufficiency ratings make it possible to set up priorities on a first-things-first basis which the public, highway users, and the legislature can understand, because they show in a single numerical value the degree of road adequacy, and the relationship of the need for improvement of any section to the need of all other sections. (Paper "A Businesslike Approach to the Highway Problem" was presented at SAE Metropolitan Section, New York, April 2, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

Paving Machinery Challenges Engineers

Based on paper by

ROY C. HEACOCK

Barber-Greene Co

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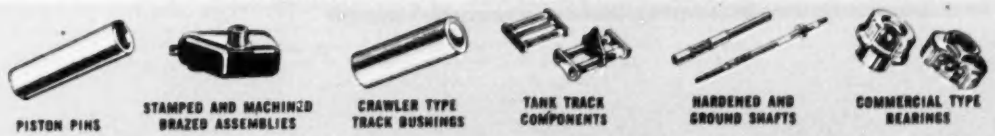

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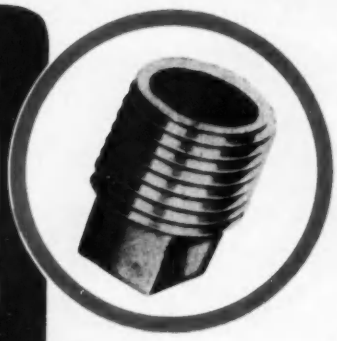

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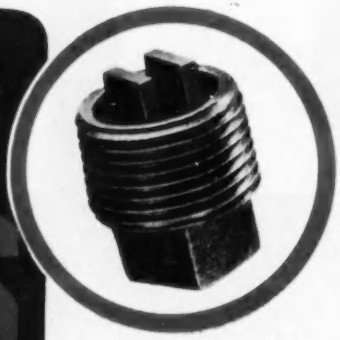
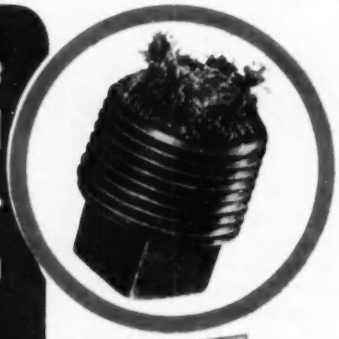


To Remove IRON and STEEL Particles from Oil . . .



Write for FREE sample plug for testing

STATE SIZE AND TYPE OF LISLE PLUG DESIRED

LISLE Corporation

1903 – GOLDEN ANNIVERSARY – 1953

CLARINDA, IOWA

from a central plant is usually laid with a mechanical paver or finisher.

The Barber-Greene machine is full crawler mounted and of the tamping self-levelling type. Mix is discharged into the receiving hopper by trucks, from which feeders take the material back and dump it on the base. A spreading screw carries the material out to the full width being laid. The screed and tamper assembly then tamp, level, and smooth the material into the desired smooth finished mat. Rolling gives the pavement its final set as it cools. The tamper and screed assembly are carried on two levelling arms which are pivoted at the forward end of the chassis crawler frames. The assembly is free to ride as it will on the mat surface, the thickness being controlled simply by the angle to which the screed is set with reference to the base on which the machine is operating. This machine will lay a mat from eight to 14 ft wide, up to 6 in. thick, up to speeds of 44 ft per min.

We have many design problems. We need cheaper materials which are more highly resistant to abrasion and wear. Control elements having a high degree of accuracy and long life under dirty conditions are important. Simpler and cleaner dust handling systems are very desirable. Quicker and cheaper plant erection methods are much wanted by our contractor customers. More portability and roadability are sometimes in the forefront of any list of desirable improvements. The biggest challenge we face is in basic approach and arrangement, in contrast to a field such as concrete mixers where designs have been fairly well standardized. (Paper, "Asphalt Paving—The Finishing Touch," was presented at SAE Central Illinois Section Earthmoving Industry Conference, Peoria, April 8, 1953. It is available in ful lin multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

Social Engineers Are Pseudo Engineers

Based on paper by

ADMIRAL BEN MOREELL

Jones & Laughlin Steel Corp.

SOCIAL engineers are dedicated to the thesis that by using the force of government, mankind in the mass can be changed and molded to conform to a master plan, in much the same way as engineering materials can be processed in accordance with preconceived designs.

We scientific engineers have the unchanging laws of chemistry, physics, and the other natural sciences to guide our efforts. The social engineers either know nothing of nature's immutable

1953 Mobilgas Economy Run Proved Again

B-W Overdrive *pays off!*

Top 9 cars (on miles-per-gallon basis) including Sweepstakes winner—all equipped with this famous Borg-Warner Transmission unit—averaged

25.27 MILES PER GALLON

Again this year the records proved: B-W Overdrive means more miles per gallon of gas!

In the grueling, 1206.1-mile Mobilgas Economy Run—sanctioned and supervised by the Contest Board of the AAA—the 9 best actual miles-per-gallon records were made by 1953-model cars equipped with Borg-Warner Overdrive.

And in *every* year of this annual contest, the *ton-miles-per-gallon* Sweepstakes winner has been equipped with this famous Borg-Warner transmission unit.

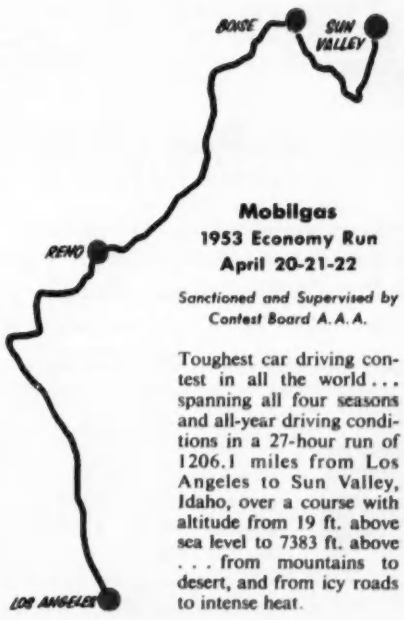
What better proof could you want of real fuel economy!

SAVES GAS—CUTS ENGINE WEAR

An advanced-type transmission, B-W Overdrive automatically cuts engine revolutions 30%. At 50, for instance, the engine is taking it easy at only 35! That saves gas. Saves engine wear, too—means longer life and fewer repair bills.

Made exclusively by B-W's Warner Gear Division, Overdrive is now offered on 13 leading makes of cars. Proof again that . . . *B-W engineering makes it work—B-W production makes it available.*

Borg-Warner



Mobilgas
1953 Economy Run
April 20-21-22

Sanctioned and Supervised by Contest Board A.A.A.

Toughest car driving contest in all the world . . . spanning all four seasons and all-year driving conditions in a 27-hour run of 1206.1 miles from Los Angeles to Sun Valley, Idaho, over a course with altitude from 19 ft. above sea level to 7383 ft. above . . . from mountains to desert, and from icy roads to intense heat.

ENGINEERING B-W PRODUCTION

THESE UNITS FORM BORG-WARNER, *Executive Offices, Chicago:* ATKINS SAW • BORG & BECK • BORG-WARNER INTERNATIONAL • BORG-WARNER SERVICE PARTS • CALUMET STEEL • CLEVELAND COMMUTATOR • DETROIT GEAR • FRANKLIN STEEL • INGERSOLL PRODUCTS • INGERSOLL STEEL LONG MANUFACTURING • LONG MANUFACTURING CO., LTD. • MARBON • MARVEL SCHEBLER PRODUCTS • MECHANICS UNIVERSAL JOINT • MORSE CHAIN MORSE CHAIN CO., LTD. • NORGE • NORGE HEAT • PESCO PRODUCTS • REFLECTAL • ROCKFORD CLUTCH • SPRING DIVISION • WARNER AUTOMOTIVE PARTS • WARNER GEAR • WARNER GEAR CO., LTD. • WOOSTER DIVISION

Castings by National

selected for Quality and Dependability

Products bearing these familiar trademarks have all established enviable reputations for quality and dependability. And to guard product reputations, these manufacturers *continue* to specify castings by National —one of the Nation's largest founders.

DETROIT QUALITY GEARS
Nash
STUDEBAKER
HYDRAPOWER Gross
FRUEHAUF TRAILERS
HUDSON
Ford
GEMMER MANUFACTURING CO.
HYDRAGUIDE

National's unparalleled experience in producing malleable, heat-treated malleable, and steel castings is at your disposal. Sales offices and engineering facilities are located at all five strategically located plants.

A-5855

PLANTS LOCATED IN Sharon, Pa., Cleveland 6, Ohio, Indianapolis 6, Ind., Melrose Park, Ill., and Chicago 50, Ill.

SEE "This Moving World"

A 16mm Technicolor film. Narrated by Edwin C. Hill, this 27-minute film tells how malleable iron is made . . . tested . . . used . . . how its production economy, ductility, machinability, toughness will give you a better finished product. Available for group showings.

NATIONAL Products FOR TRANSPORTATION AND INDUSTRY

NATIONAL MALLEABLE and STEEL CASTINGS COMPANY
CLEVELAND 6, OHIO Est. 1868

laws, or choose to ignore them. Instead, they have their man-made and variable laws of compulsions, prohibitions, and other restrictions on the free actions of individuals.

Scientific engineers process raw materials to create products for the service of mankind. Social engineers use raw material—human beings—to create products designed to serve and please their own fancy, and frequently to satisfy their craving for personal power. (Paper, 'Engineers—Scientific and Social," was presented at SAE Annual Meeting, Detroit, Jan. 14, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

Need Long Range Plan To Cut Air Power Costs

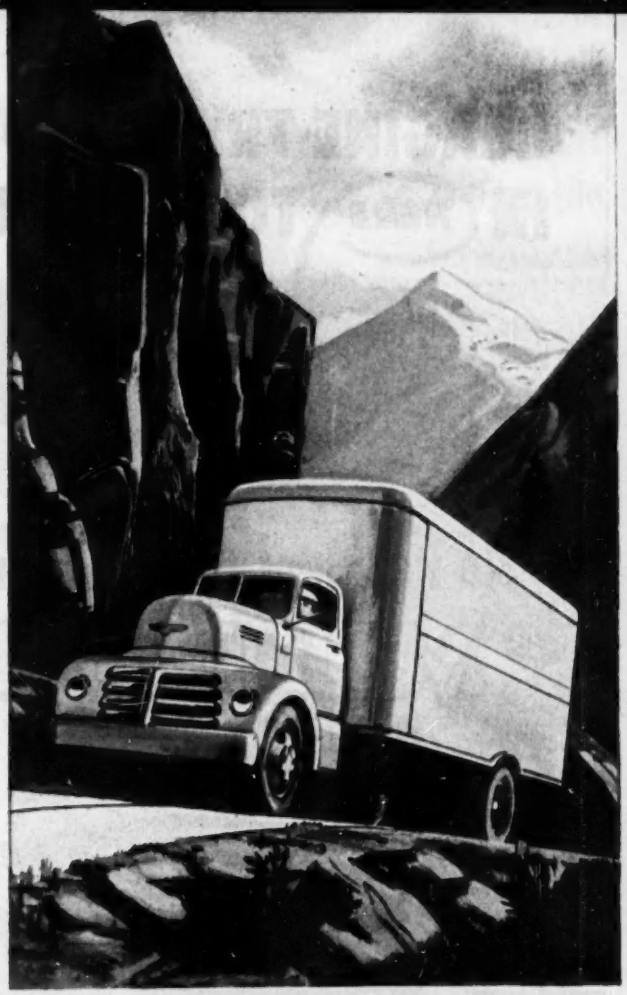
Based on paper by

MUNDY I. PEALE
Republic Aviation Corp.

THE best way to give the American taxpayer a break, yet provide him with the security of air supremacy in the face of a terrible threat, is to adopt a sane and sensible airplane procurement program, designed to keep us abreast or ahead of the potential enemy. We cannot go on shoving money into vending machines on the spur of the moment and have real air power come out. Bulding and maintaining air power requires a sane and sober program, not a program of panic.

Savings substantial enough to be felt by individual taxpayers can be made in the area of long range planning alone. They cannot be achieved by stop-and-go procurement such as has characterized our air power program thus far.

We must realize as well that today's incredibly fast and complex aircraft have produced a technological revolution in engineering with all the new things to be worked out in jets, atomics, electronics and the rest. The lead time to bring new planes into being is lengthening. We are constantly working to reduce flow time, but certain components seem to require just so much time—and without them you can't have an airplane. We should never forget that not a single one of the airplanes developed during World War II saw combat in that war. We are working today with planes which cannot be produced until the late 1950's and early 1960's. (Paper "U.S. Airpower—Today and Tomorrow" was presented at SAE National Aeronautic Meeting, New York, April 23, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).



Hypoid Gearing

CUTS TRUCK MAINTENANCE COSTS —ADDS EXTRA MILEAGE

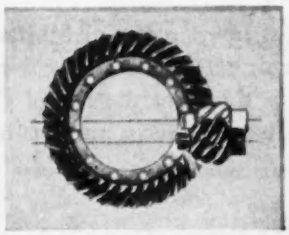
Years were spent in developing, testing and proving Hypoid for use in heavy-duty trucks

Truckers today are getting more miles per truck, under tougher operating conditions, than ever before. Such major improvements as Hypoid gearing, developed and built by TDA, are increasing truck life and reducing maintenance in spite of the heavy schedules of a defense economy.

Used on many makes of automobiles for more than a decade, Hypoid gearing is strictly a postwar development in medium- and heavy-duty truck axles. TDA, realizing its inherent advantages, spent years developing and testing before the first Hypoid-geared truck axles were placed in mass production. Today, only TDA offers Hypoid gearing in all three types of final drives—single-reduction, double-reduction and two-speed double-reduction—in a complete range of capacities.

Although a relatively new development, Hypoid truck axle gearing has been fully tried and proved. Billions of ton-miles have been rolled up in actual on-the-job operation since it was first introduced to truckers by TDA a few years ago. Find out why you should insist on rugged, dependable Hypoid gearing in the next medium- and heavy-duty trucks you buy. Write to TDA for an informative, illustrated booklet on Hypoid gearing.

A COMPLETE "INDOOR PROVING GROUND" makes it possible for TDA engineers to test heavy-duty truck axles under the same conditions as those that are actually encountered on the toughest stretches of America's highways. Truck axle torques and speeds can be reproduced, and repeated accurately, time after time. Advanced engineering facilities like this enable TDA to design and build the finest truck and bus axles in the world.



HYPOID PINION IS OFFSET FROM THE CENTERLINE OF THE GEAR. As a result the pinion is bigger and stronger. Bearings are bigger. More teeth are in contact, reducing loading per unit of contact area. Torque transmitting capacity is increased. Slower gear ratios are practical without loss of strength.

The Accepted TDA Standard

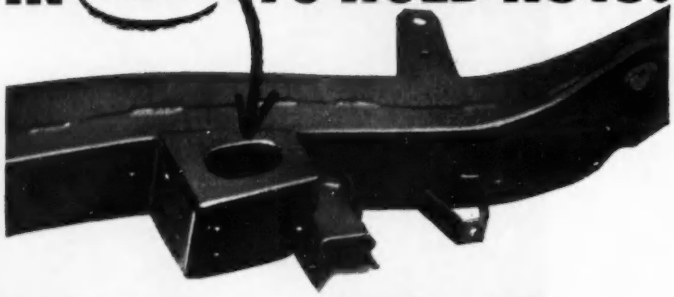
AXLES

THE TIMKEN-DETROIT AXLE COMPANY
Detroit 32, Michigan

WORLD'S LARGEST MANUFACTURER OF AXLES FOR TRUCKS, BUSES AND TRAILERS

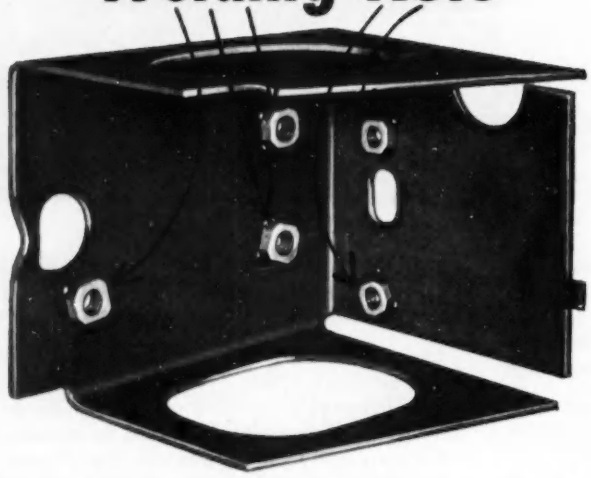
PLANTS AT: DETROIT AND JACKSON, MICH. • OSHKOSH, WIS. • UTICA, N. Y. • ASHTABULA, KENTON AND NEWARK, OHIO • NEW CASTLE, PA.

IMAGINE TRYING TO GET IN HERE TO HOLD NUTS!



No Problem At All With . . .

MIDLAND
Welding Nuts



With Midland Welding Nuts pre-mounted* in inaccessible places, there is no need to hold the nuts while attaching other parts.

*THIS IS ALL YOU DO — Just insert collar of Midland Welding Nut in hole for bolt or screw, resistance weld the Nut in place, and the Nut is there for the life of the job. Nuts can be fed automatically to the resistance welder.

Write for facts about these better connections at less cost.

The MIDLAND STEEL PRODUCTS COMPANY

6660 Mt. Elliott Ave. • Detroit 11, Michigan

Export Department: 38 Pearl St., New York, N. Y.

Manufacturers of

AUTOMOBILE AND TRUCK FRAMES | AIR AND VACUUM POWER BRAKES | AIR AND ELECTRO-PNEUMATIC DOOR CONTROLS

Students Enter Industry

Continued from Page 102

LEONARD E. HASE (University of Colorado '53) is sales engineer for the Minnesota Mining & Mfg. Co., St. Paul.

DONALD F. KROENER (California State Polytechnic College '53) is with the Sperry Gyroscope Co., Great Neck, N. Y., as field engineer.

RICHARD E. HALATEK (University of Michigan and the Chrysler Institute) is a body engineer at the Chrysler Corp., Detroit.

GEORGE R. KREISEL, JR. (Cornell University '52) is a second lieutenant in the U. S. Air Force as a radar maintenance officer.

DONALD L. WHITNEY (Academy of Aeronautics '52) is now an aircraft assembler with the Boeing Airplane Co., Wichita, Kans.

NINO ARTHUR VECCHIONI (Aeronautical University '52) is an ensign in the U. S. Navy stationed in Arlington, Va.

FRANCIS E. DAIGLE (University of Massachusetts '53) is a second lieutenant stationed at the Wright-Patterson Air Force Base, Ohio.

ROBERT E. WEIDER (Villanova College '53) is a trainee in a 30 week program at Gleason Works, Rochester, N. Y.

RICHARD W. REED (Carnegie Institute of Technology '53) has joined Babcock & Wilcox, St. Petersburg, Fla., as a draftsman-engineer.

LAWRENCE D. PORTER (Northrop Aeronautical Institute '53) is a junior engineer at Douglas Aircraft, El Segundo, Calif.

DONALD C. MARK (New York University '53) is with the U. S. Air Force Reserve, active duty.

MATHEW D. GARRED, JR. (Purdue '53) has joined the Allison Division, GMC, Indianapolis, as an experimental test stand engineer.

VERNON F. ELLIOTT (University of Saskatchewan '53) is with the Ford Motor Co. of Canada, Ltd., in a one-year training plan.

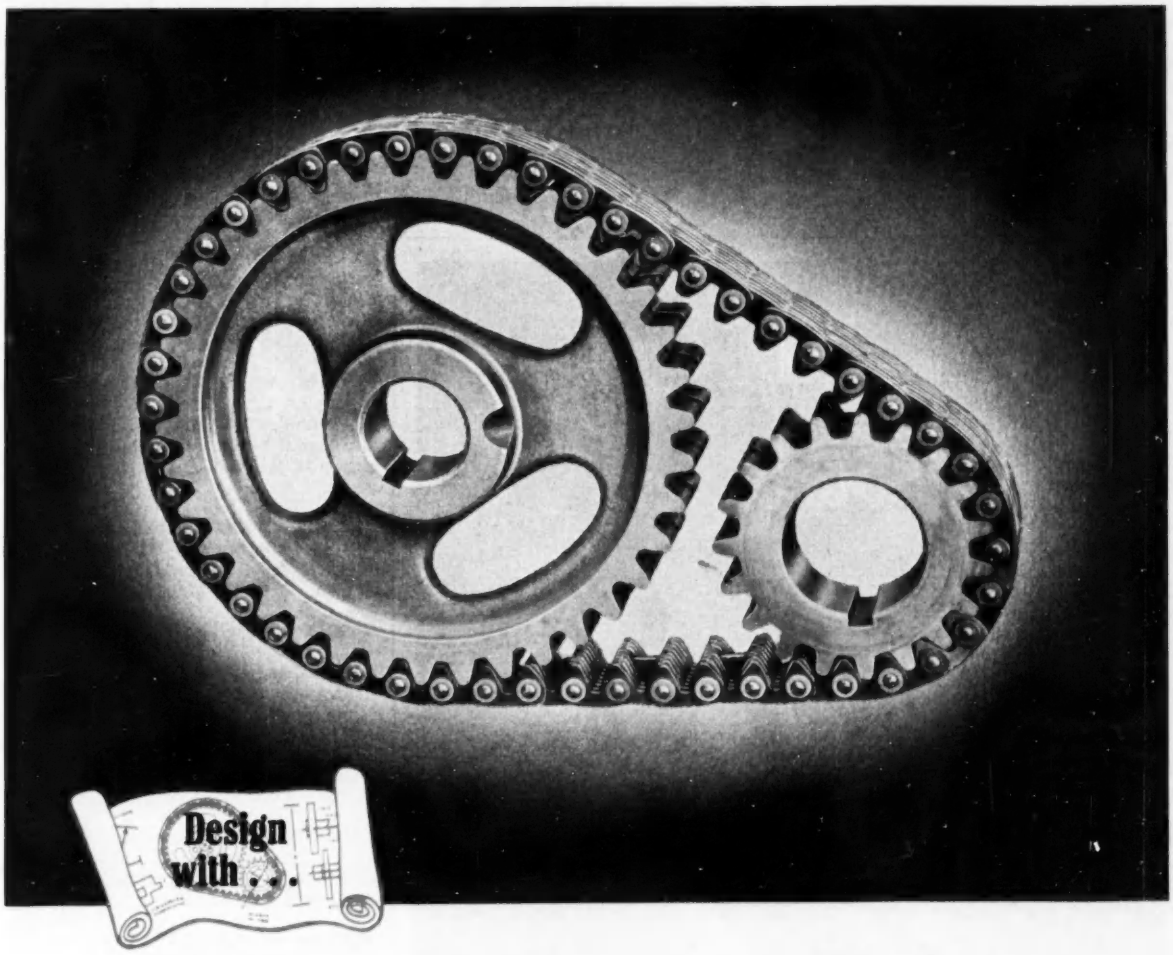
GEORGE A. DONALDSON (Parks College of Aeronautical Technology '52) is a second lieutenant with the 3401st student squadron, Keesler Air Force Base, Miss.

JOHN WILLIAM CAMPBELL (University of Saskatchewan '53) is with the Saskatchewan Power Corp., Gas Dept., Saskatoon.

Continued on Page 126

Be sure you get all 3...

✓ **Automatic joint snugness** ✓ **Smoother operation** ✓ **Longer life**



Link-Belt Timing Chain

Segmental Bushings provide automatic joint snugness

Segmental bushings are made with slight bow.

After initial assembly in chain, bushings are straight.

Bow in bushing acts to keep a snug joint, maintaining chain pitch automatically.

THE secret behind Link-Belt Timing Chain's smoother operation and longer life is the exclusive Segmental Bushing. Note in the sketches above the automatic compensation for wear—provision for complete joint snugness at all times.

Equally important, the facilities of the world's largest chain plant are your assurance of a continuing supply. Constant research keeps you informed on latest technical advances. Engineering and specification details are in Book 2065.

LINK-BELT

TIMING CHAINS and SPROCKETS

LINK-BELT COMPANY: 220 South Belmont, Indianapolis 6, Ind. Offices in principal cities. 12,742

Students Enter Industry

Continued

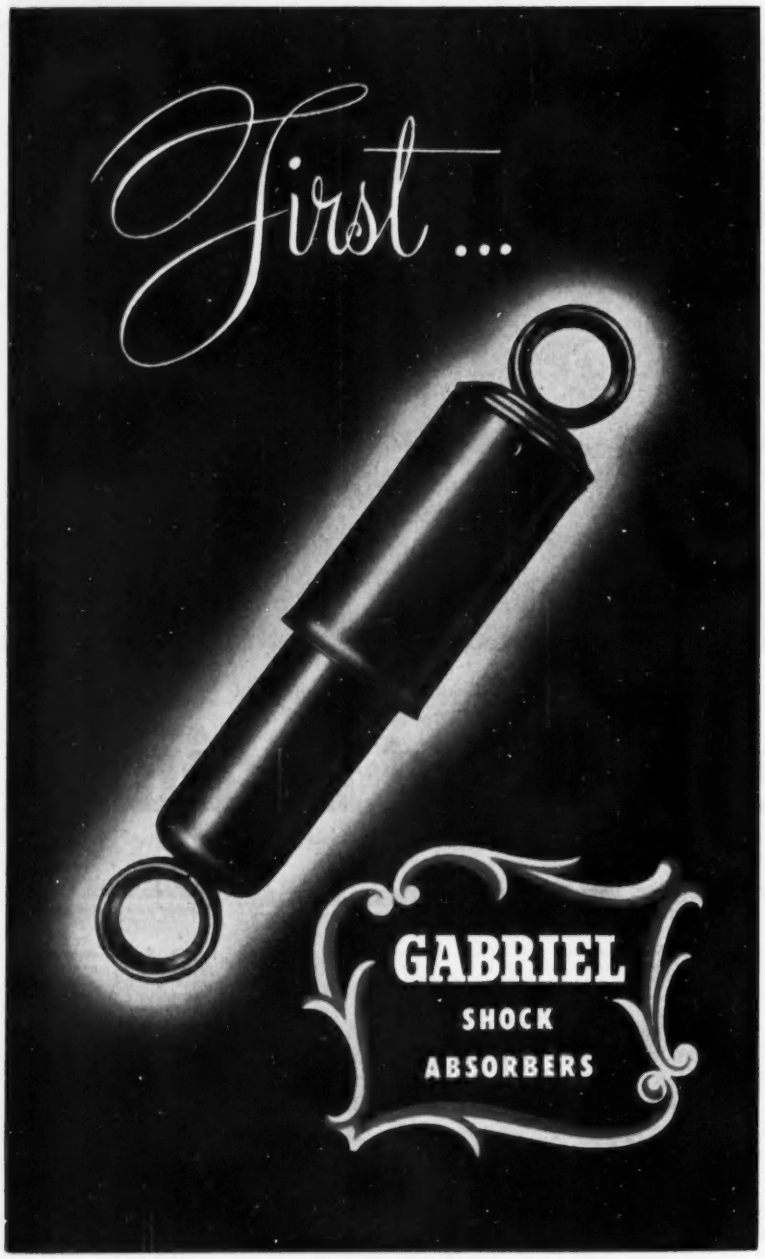
DON L. DELANO (University of Michigan '52) is in the U. S. Army.

LYMAN F. BUSKIRK (Missouri School of Mines & Metallurgy '52) is now a mechanical engineer at the U. S. Naval Ordnance Test Station at China Lake, Calif.

CLIFFORD M. RIGSBEE (U. S. Naval Academy '51) is now a naval aviator in the U. S. Navy. He is stationed at Ellyson Field, Pensacola, Fla.

STANLEY P. FUNKHOUSER (Indiana Technical College '50) is now working as a development engineer at the Tapco Plant of Thompson Products, Inc., Cleveland, Ohio.

R. VENKATESWARAN (Madras Institute of Technology '52) has joined the Sundaram Motors, Ltd., Madras, India, as an engineer apprentice.



RICHARD W. SLY (Michigan College of Mining & Technology '52) is a junior engineer in the Diesel Experimental Department of Fairbanks, Morse and Co., Beloit, Wis.

EDWIN P. SCHLINGER, JR. (California Institute of Technology '52) is now a second lieutenant in the U. S. Air Force. He is stationed at Vallejo, Calif.

WILLIAM REID SMITH (University of Pittsburgh '52) has joined the General Motors Research Laboratories Division, Detroit, as a junior engineer.

RAYMOND P. O'CONNELL (Case Institute of Technology '52) is now a junior engineer with the Cleveland Electric Illuminating Co., Cleveland, Ohio.

GERALD W. De LOY (Lawrence Institute of Technology '52) has joined the Brunswick-Balke-Collender Co., Muskegon, Mich., as an industrial engineer in the tool engineering department.

OMER C. DeCLERCQ (Lawrence Institute of Technology '52) is now sales engineer for the New Departure Division of General Motors, Detroit.

HENRY J. SOSSONG (Indiana Technical College '51) has joined Reaction Motors Inc., Dover, N. J., as an assistant engineer.

DONALD V. ROBINETT (University of Cincinnati '51) is a second lieutenant in the U. S. Army Ordnance Corps stationed at Huntsville, Ala.

CAROL D. ROSE (Lawrence Institute of Technology '52) is now with the Dow Chemical Co., Midland, Mich. as a mechanical engineer.

ALBERT W. RATUSH (Lawrence Institute of Technology '50) is in training with the Fisher Body Division of General Motors.

RICHARD G. BUTTON (Case Institute of Technology '52) is with the General Electric Co., Cincinnati, Ohio, as a technical engineer.

WILLIAM T. Der GARRY (University of Florida '52) is a second lieutenant in the U. S. Army stationed at Ft. Benning, Ga.

STANLEY H. RAFFEL (University of Maryland '53) has joined the Ralph M. Parsons Co., Braddock Heights, Md., as a junior engineer.

DALE H. DANALDS (Indiana Technical College '52) is now in the U. S. Army, stationed at Fort Riley, Kans.

PAUL H. GUIMARAES (Rensselaer Polytechnic Institute '52) is with

Continued on Page 128

The Most Satisfactory
IGNITION CONTACT
Ever Designed!

Let us design the Contacts for your equipment—or we will make them to your specifications

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Ignition

A PRODUCT OF ECHLIN

CONTACTS
COILS -- CONDENSERS
& OTHER AUTOMOTIVE
ELECTRICAL PARTS

ECHLIN MANUFACTURING COMPANY • DEPT. SAJ, 200 EAST STREET, NEW HAVEN 5, CONN.

Students Enter Industry
Continued

Douglas Aircraft Co., Inc., Santa Monica, Calif., as a research laboratory analyst.

BOBBY G. DUDLEY (Parks College of St. Louis University '50) is an instructor in the department of transportation training, U. S. Air Force, Denver, Colo.

WILLIAM H. EASSON (Illinois Institute of Technology '52) is now a junior engineer with the Shell Oil Co., Wood River, Ill.

RAYMOND L. FELLER (University of Pittsburgh '52) is a management candidate with the United States Steel Co., Dravosburg, Pa.

JOSEPH N. FRENETTE (McGill University '52) is a resident engineer with the Provincial Road Department, Quebec, Canada.

MYRON R. DAY (Fenn College '52) has joined the Day Piston Co., Cleveland, Ohio, as an engineer-machinist.

WILLIAM WANG (Cal-Aero Technical Institute '52) is now a tool designer with the Gladden Products Corp., Glendale, Calif.

PAUL G. RACICOT (University of Detroit '52) is now with the Oro Mfg. Co., Adrian, Mich., as a project engineer.

RALPH H. CHILTON (Purdue University '52) is now an ensign in the U. S. Navy. He is attending Flight Training School at Pensacola, Fla.

RICHARD F. BARBIAN (Carnegie Institute of Technology '52) has joined Pratt & Whitney Aircraft, East Hartford, Conn., as an experimental test engineer.

JAMES COATS (Case Institute of Technology '52) is now with the National Advisory Committee for Aeronautics, Cleveland, Ohio.

AMIYA KUMAR BANERJEE (University of Washington '52) is a designer and mechanical engineer at the Harza Engineering Co., Chicago.

STEPHEN M. LOMAKOSKI (Wayne University '53) has joined the V. L. Graf Co., Romeo, Mich., as a project engineer.

JAMES F. ALBRECHT (Michigan State College '52) is now a service training representative with Detroit Diesel Engine Division of General Motors.

WILLIAM ROBERT HARWOOD, JR. (George Washington University '52) has joined the Tripac Engineering Corp., Silver Spring, Md., as a mechanical engineer.

MAX P. HITSCHMANN (Newark College of Engineering '52) is in the U. S. Army. He is stationed at Fort Eustis, Va.

ROY A. HINCHLIFFE (Northrop Aeronautical Institute '52) has joined Northwest Industries, Edmonton, Alberta, as a project engineer.

ROBERT ALAN HILL (Stevens Institute of Technology '52) is now a sales engineer with the American Blower Corp., Detroit, Mich.

JAMES P. GALM (Ohio State University '52) is now a project foreman in the Maintenance Department of the Diamond Alkali Co., Painesville, Ohio.

assure dependable power on this

Oil Well Drilling Rig

In isolated oil fields where water scarcity presents a terrific problem . . . only with radiators can you save and conserve water used on these giant drilling rigs. And builders of drilling rigs have found YA Sectional Cast Tank Radiators the answer for assured dependability and water conservation.

These 6 section radiators permit easy repair in the field. Any section damaged can be removed for repair, and replaced in the meantime for continued operation.

If you are a builder of heavy duty machinery, Yates-American will be glad to work with you in building radiator equipment to fit your specifications.

California Representative: E. E. Richter & Son, Emeryville, Cal.

YA

Heat Transfer Products Division

Yates-American

BELOIT, WISCONSIN

BRANCH OFFICES: CHICAGO, ILLINOIS; HIGH POINT, NORTH CAROLINA; MEMPHIS, TENNESSEE; PORTLAND, OREGON

New Members Qualified

These applicants qualified for admission to the Society between June 10, 1953 and July 10, 1953. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (SM) Service Member; (FM) Foreign Member.

Atlanta Group

George W. Peckham (J).

Baltimore Section

Maurice Elmer Ensor (A).

British Columbia Section

John Alexander McPhee (A), Gordon Lester Wilson (M).

Buffalo Section

Donald Turrentine (J).

Canadian Section

Willard O. Burgoon (J), Charles Ernest Comiskey (J), Norman Hamilton Dalziel (M).

Central Illinois Section

Max Edward Butterfield (J), William G. Carroll (A), Richard M. Edwards (J), Howard W. Huette (M), Bernard F. Kupfert (J), Russell W. Larson (J), William L. Sprick (J), Floyd J. Wingert (A).

Chicago Section

Leo M. Brieske, Jr. (M), Earl W. Bryan (A), Harry Butcher, Jr. (M), W. F. Collins (M), Ernest Ray Cunningham, Jr. (J), Richard L. Fleshman (M), Frank Iwatsuki (J), Richard E. Lyons (J), W. L. Nauman (M), Raymond Peter Niesman (M), William P. Spencer (M), Te Fung Yeh (M).

Cleveland Section

Charles B. Collins (J), Charles C. Dick (J), Ralph H. Erlanger (M), John V. Gallagher (M), Richard J. Henderson (J), Charles W. Howard (A), Ambrose John Ilg (M), Virgil P. Jenney (M), Richard Allen Koss (J), Wilton Margrave (M), Marius J. Merlin (M), Wallace H. Nichols (M), Leland H. Schmohl (M), Kenneth Leonard Selby (M), Robert E. Sheahan (M), Walter Everett Stewart (M), John E. Stott (M), Robert H. Sweeney (J), C. Jos. Yuncker (M).

Colorado Group

William J. Holtman (M).

Detroit Section

John Adams (M), Marvin John Arnold (J), Raymond J. Bergin (J), Ralph Frank Berlucchi (M), Eric Betterman (M), Laverne R. Biasell (M), Lawrence E. Bixby (M), Joseph W. Brichta (A), G. Arthur Brown, Jr. (J), Jeremiah D. Burns (A), Harry M. Casebeer (J), Paul Chuba (J), Donald E. Cox (J), Christopher Michael Drew (J), Fred N. Eaton (M), Floyd Fair (J), Paul W. Fair (J), Lothrop M. Forbush (M), Harold Sidney Friedman (J), C. E. Fulp (A), Rollin R. Galloway (M), Paul Goetcheus (M), George S. Gurin (M), Robert Lewis Hauser (J), Thomas E. Hustead (A), Lewis Francis Jilbert (J), Richard S. Karbowski (A), Russell S. Knecht (A), Robert H. Knickerbocker (J), Fred Lyijynen (M), Joseph Mihacsi, Jr. (J), Otto Morton Nedved (J), George C. Nowicki (J), Joseph Martin Prisner (M), D. K. Rennie (M), Sydney W. Reseigh (J), Louis E. Rhodes (M), Jesse W. Richards (M), William D. Route (M), Wil-

Continued on Page 131

Precision Filaments Mean Uniform Lamp Candlepower

Safety on our highways after dark depends mainly on the illumination provided by the headlamps of cars, trucks and buses. One of the many critical operations in the making of lamps capable of delivering correct candlepower, is filament winding.

The picture shows tungsten wire filaments for Tung-Sol lamps being wound and shaped automatically to microscopic tolerances by high speed machines. This is the manufacturing tempo by which Tung-Sol supplies millions upon millions of lamps of every type to the automotive industry.

Although volume is essential, quality always comes first with Tung-Sol. Rigid production and quality control procedures hold Tung-Sol lamps to standards for uniform electrical and light characteristics that are unsurpassed in the industry.

Tung-Sol will gladly assist you with any miniature lamp application.

TUNG-SOL ELECTRIC INC., Newark 4, New Jersey

Sales Offices: Atlanta, Chicago, Columbus, Culver City (Los Angeles), Dallas, Denver, Detroit, Newark, Philadelphia, Seattle.

TUNG-SOL®
DEPENDABLE
AUTO LAMPS

TUNG-SOL makes All-Glass Sealed Beam Lamps, Miniature Lamps, Signal Flashers, Picture Tubes, Radio, TV and Special Purpose Electron Tubes and Semiconductor Products.

moraine-400

...the bearing that helps new engine designs come true

Because they remove bearing *length* as a limiting factor in engine design, Moraine-400 bearings help to make more compact engines of higher horsepower possible.

For example . . . one of our customers is now developing an engine that will have impressively greater output without greater bulk. Its features include a stiffer crankshaft, larger pistons, more rigid connecting rods . . . and, because Moraine-400s are being used . . . *narrower bearings!* In addition, tests indicate that bearing life will be increased as much as *400 per cent!*

May we suggest that your engineers consider Moraine-400 bearings in designing and developing your engines of the future.

moraine products

DIVISION OF GENERAL MOTORS CORPORATION • DAYTON, OHIO

New Members Qualified

continued

liam E. Safar (A), Herbert L. Sanborn (A), Clifford W. Sponsel (M), Edward J. Stackwell (J), Roy E. Sunday (J), Charles Edward Terrill (J), John L. Thousand (J), Robert J. Trevillyan (M), Harold Joseph Tuchyner (J), William J. Ulrich (M), Thomas D. Weiser (M), Frederick G. White, Jr. (A), Thomas Gould Whittingham (J), Bruce O. York (M).

Hawaii Section

Robert K. McGill (M), Carl J. Rossetti (J).

Indiana Section

Wayne H. Glover (M), Levi C. Mock (A), Herman James Redd (M), David C. Redick (M), Louis R. Russell (M), William V. Ryan (A), Robert W. Secrest, Jr. (J), M. F. Trevey (M), Stuart Wilder, Jr. (M).

Kansas City Section

Charles H. Dunham (A), John W. Lynch (A), Eugene E. Strotheid (A).

Metropolitan Section

H. D. Alsdorf (M), Michael DeAdamo (A), Walter Frazer (A), Russell C. Grube (M), Martin A. Kottler (A), Robert S. Mullaney (M), Walter H. Niedermeier (A), E. R. Noble (A), John F. Pereira (J), Warren R. Petersen (M), James Richmond-Crum (M), Warren E. Ring (J), Gary Schleimer (A), John S. Steele (A), Frank W. Tchitcherine (A), C. Dunham Tilden (A), Harry Wright (M).

Mid-Michigan Section

William S. Kenyon, Jr. (M), Russell C. Martz (A), Harold T. McGrath (M), Frank Pritchard (J), Lucian B. Smith (M), Roy S. Thornburgh (M), Joseph J. Verbrugge (M).

Milwaukee Section

Robert J. Dunlap (J), Gerald E. Gilbertson (J), Frank P. Kuether (M), Arnold F. Lueders (A), Aristotle Paras (J), Donald H. Paul (M), C. Frank Riddle (M), Donald W. Schmitt (M), Harrison Weaver, Jr. (M).

Mohawk-Hudson Group

Irving L. Barger (J), Newell N. Davis (M), Louis G. Kropacek (M), Edward C. Roberts (M), Kenneth C. Spooner (A), Norman Frank Taylor (J), Rene Antoine Michel Toesca (M).

Montreal Section

Georges L. Archambault (M), Stephen J. Barney (M), Arthur M. Gittins (A), Walter P. MacGillivray (A).

New England Section

Raymond Kenneth Andrew (M), Stanley T. Athas (J), Herbert P. Bagley, II (A), Fred Joseph Croce (A), Jack S. Crusoe (A), David I. Driscoll (M), Charles F. (Ted) Koopman, Jr. (A), Richard Lawrence (M).

Northern California Section

Leonard Gordon Keating (A).

Oregon Section

John B. Allin (A).

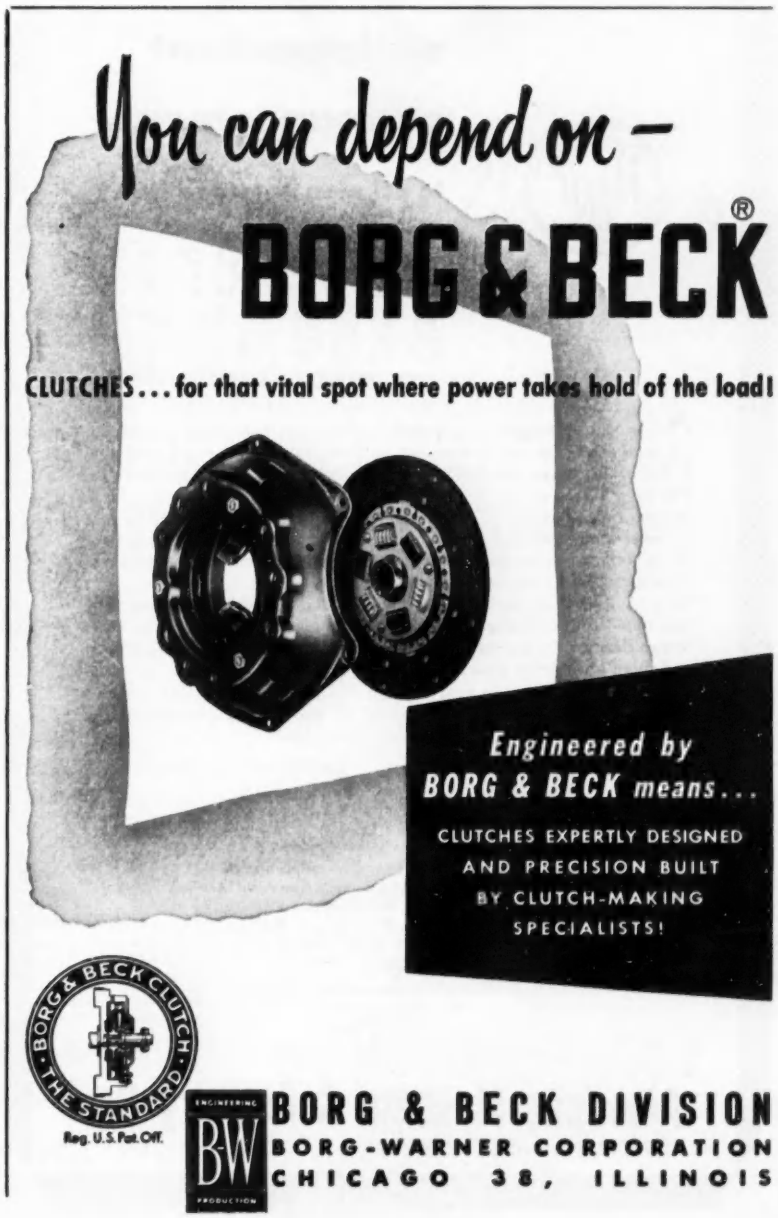
Northwest Section

Robert E. Johnson (M), Edwin R. Strohm (A).

Philadelphia Section

John R. Anderson (A), Milton W. Dalrymple (M), Earl H. Lewis (A), Mrs. Cathryn H. Williams (A), Warren E. Young (A).

Continued on Page 132



New Members Qualified

continued

Pittsburgh Section

Charles Bello (M), Rankin J. Bush (M), H. R. Fife (M), William G. Stanier (A).

St. Louis Section

Gerald C. Donnan (A).

San Diego Section

C. Roy Barber (A), John G. Hamilton (M), William T. Immenschuh (M), Lt. Berger Velander (J).

Southern California Section

Royce Carvel Blood (M), D. E. Bowers (M), James Andrew Broadston (M), A. J. Drusch, Jr. (M), Frederick S. Howard (J), Fred T. Miller (M), Ralph Edward Owens (A), James A. Padden (A), Gernot Strauss (J).

Southern New England Section

William W. Jacobus (M), Donald H. Merry (A), Edwin A. Nichols (A), Claude F. Waldron, Sr. (M).

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Mechanics Research Department

American Machine & Foundry Co.

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Spokane-Intermountain Section

Henry L. Peirone (A), Elroy W. Schultz (A).

Syracuse Section

Edward Francis Hannon (M), Richard E. Posthauer (M), Donald G. Ritchie (J).

Texas Section

Howard R. Carlson (A), Robert L. Wallace (J), Benjamin F. White (J).

Texas Gulf Coast Section

Charles D. Kemp (A).

Washington Section

Gabriel C. Danch (M).

Western Michigan Section

Armen V. Babayan (M), William Carpenter (M), Clarence E. Hanson, Jr. (A), George A. Spoon (M), Albert E. Whitney, Jr. (J), Lawrence H. Workman (M).

Outside Section Territory

John C. Daniels (A), William James Esdale (M), Harold G. Everett (A), Orvin Ellsworth Flint (J), Herman Gerber (A), Robert W. Holder (M), Alphonse A. Jacobellis (J), Joseph E. Kirk (M), Layton R. Milton (M), George Reindel, Jr. (A), Joseph Sharpe (J), John Toper (J), J. P. Wagner (M), Philip F. Walters (M), Bernard William Wortelboer (M).

Foreign

Paul Beebe (M), Japan; Rodolfo Martinez DeVedia (M), Argentina; Sigvard Forssell (M), Sweden; Geoffrey Robert Greenbergh Gates (M), England; Willy Huter (M), Switzerland; Royston Charles Lunn (M), England; Victor Stanley Porter (A), England; Robert James Herbert Soanes (M), England; Eugen Stump (M), Germany; Sven-Olof Svantesson (M), Sweden.

Another First for Thompson

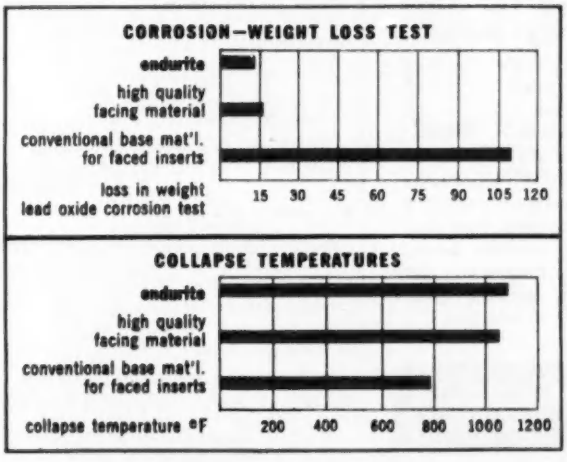
Thompson, which pioneered in the development of super-hard, heat resisting alloys for valve seat inserts now has engineered a new, even better valve seat material—*Endurite*.

Endurite has all of the properties of the best heavy duty valve seat facing materials *plus* superior lead corrosion resistance *plus* superior resistance to insert seat collapse or loosening.

Seats made of Endurite stay tight in the cylinder head or block and also permit more regrinds, since Endurite is not used as a facing only. The *entire* seat is Endurite.

If you have a valve seat insert problem in your gasoline, diesel or propane engine, write or phone Special Products Division, Thompson Products, Inc., 2196 Clarkwood Road, Cleveland 3, Ohio.

These charts indicate Endurite superiority over other types of materials used in valve seat insert manufacture.


CORROSION—WEIGHT LOSS TEST
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conventional base mat'l. for faced inserts
loss in weight lead oxide corrosion test
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COLLAPSE TEMPERATURES
endurite
high quality facing material
conventional base mat'l. for faced inserts
collapse temperature °F
200 400 600 800 1000 1200

You can count on

Thompson Products

SPECIAL PRODUCTS DIVISION

Applications Received

The applications for membership received between June 10, 1953 and July 10, 1953 are listed below.

Atlanta Group

Cecil R. Stockard.

Baltimore Section

Milton D. Behrens, Harry Thomas Cline, C. David Haacke.

British Columbia Section

William M. McGowan.

Buffalo Section

William H. Gratz, Arthur W. Kuhn, Willis Sprattling, Jr.

Canadian Section

Clayton A. Cook, Donald Stevens Wood.

Central Illinois Section

A. Richard Ayers.

Chicago Section

Ted del Solar, John Bruce Ingold, Harry Lucas, Nathan Theodore Mann, William L. McNulty, Robert O. Neff, Ray A. Trapp.

Cincinnati Section

Peter G. Belitsos, Jeremie Joseph Kaelin.

Cleveland Section

David Ralph Bonnes, Alfred Crease, Gail F. Davies, Don F. Harroff, Thomas W. Lauer, Albert J. Phillips, Thomas R. Stefancin, Walter Robert Tuuri.

Colorado Group

Richard P. Bobco.

Dayton Section

R. M. Conklin, John A. Taylor.

Detroit Section

Joseph John Adamo, John V. Capinjola, James A. Caulfield, Ernest DeFusco, Donald Droste, Wiliam James Eubank, Joseph Richard Farnham, Peter J. Gallette, Herbert H. Haas, Werner E. Hamann, John F. Hern, Joseph J. Hoffmann, Jimmie James, Donald Ferris Kopka, Calvin F. Long, Raoul J. Pepin, Dale K. Pettry, Thomas G. Pillifant, Holman S. Robertson, John James Rodgers, Vern Dean Shipley, Ralph C. Stahman, David W. Stapleton, Kenneth A. Stonex, J. M. Sturm, Raymond J. Symons, Robert Blair Thornhill, Francis J. Weber, Adolf A. Widmann, Warren M. Wiese, Kenneth William Verge, Maurice M. Welsh, David C. Wright.

Hawaii Section

Charles M. Tolstrup.

Indiana Section

Eugene Josef Geiger.

Kansas City Section

Kenneth J. Greening, John M. Walker.

Metropolitan Section

K. C. Bernes, John Edmund Cammack, Harold Thomas Larkins, John Maranchik, Jr., Rayner Colbourne Powell, Hiram Edward Searles.

Mid-Michigan Section

Donald C. Burnham, Harry C. Doane, Howard William Gray, Ken-

Continued on Page 136

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The wide gauge and high ground clearance of the American Terratrac help it "keep its feet" on steep slopes — and keep the engine out of mud and water, up to 27" deep. ROCKFORD CLUTCHES help it perform the toughest dozer jobs in slippery going. Let ROCKFORD clutch engineers help solve the difficult power transmission control problems of *your* heavy-duty machines.

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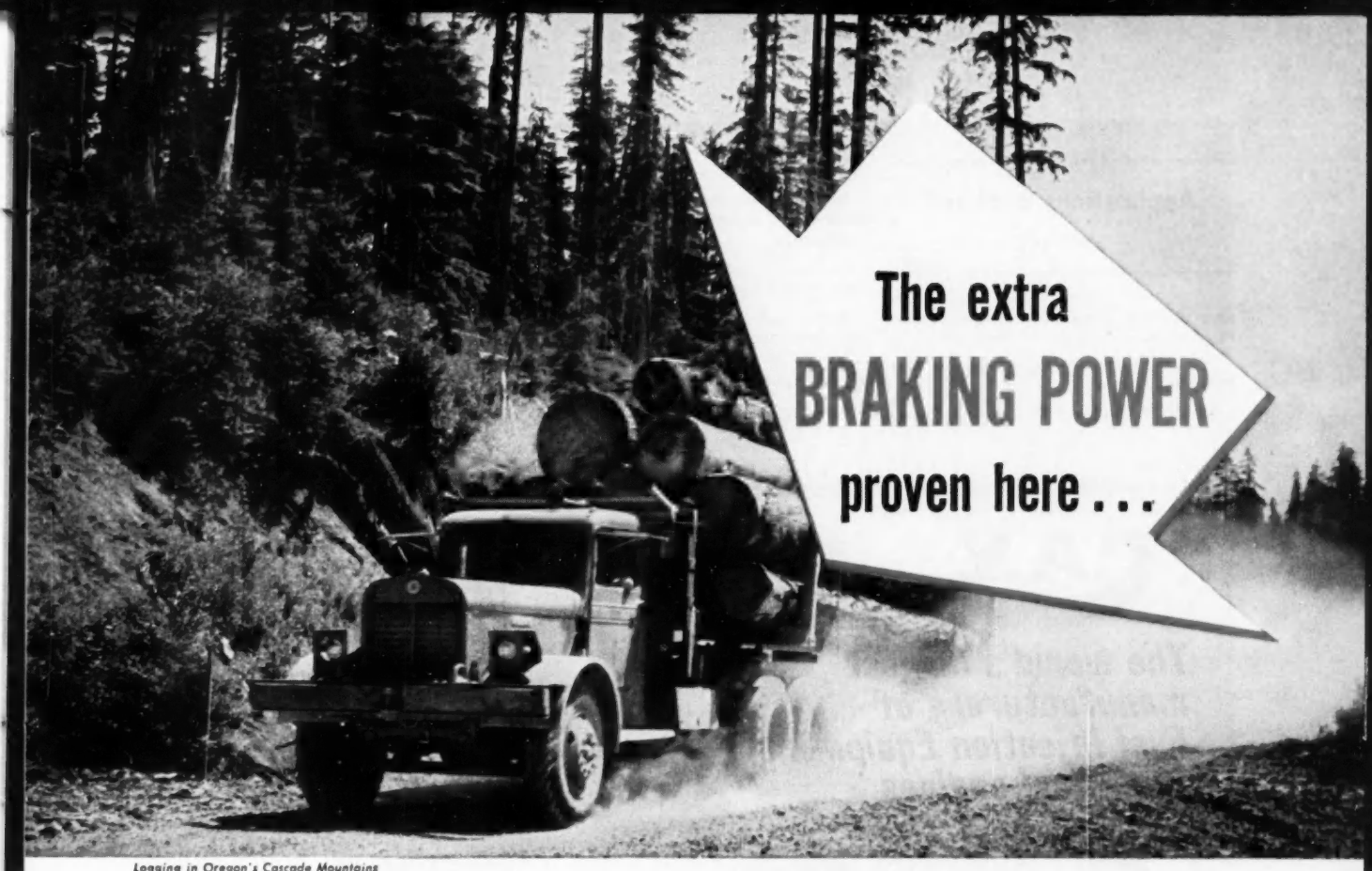

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Applications Received

continued

neth R. Hill, Philip C. Servais, Robert M. Sinclair, Darwin K. Sohmer.

Milwaukee Section

Ralph T. Huntley, Douglas E. Peash.

Montreal Section

William George Beamish, Andre R. Ducharme, Alain Prefontaine, Nicholas Roehrberg.

New England Section

Edward F. Donahue, Monroe A. Maller, John Russell Thompson.

Northern California Section

Dirk VanderBurch, John Y. Wong.

Northwest Section

Thomas G. Taxelius, Robert L. Wilson.

Philadelphia Section

Albert V. Cabal, George G. Cudhea, Carson DeCash, Jr., Kenneth A. Frassa, John Joseph Gricius, Edward T. Kennedy, Charles Ponti, David W. Shearston.

St. Louis Section

William Elliot Williamson.

Salt Lake Group

Hashim M. Sanduk.

San Diego Section

Robert Charles Hinck.

Southern California Section

Alfred E. Andreoli, Mario S. Bonura, Donald Bruce Epner, Richard S. Fairall, George S. Schatzman, Herman James Schneider, George William Soto, William G. Warner, Morton H. Wolk.

Southern New England Section

Michael Joseph Geremia, Stanley L. Leavitt, Charles Emerson Norton, Edward William Presbie, Joseph A. Rice, Ervin E. Schiesel.

Spokane-Intermountain Section

Charles Elbert Webb.

Texas Section

Otto A. Dworak, Homer E. Edwards, Henry C. Jones, Victor C. Kobold.

Texas Gulf Coast Section

C. A. Welling.

Washington Section

Ivo M. Amaral, Fenner N. Spivey, Lt. George W. Stetson, III.

Western Michigan Section

Elmer Frederick Hartley, John D. Krehbiel.

Wichita Section

Howard J. Agnew.

Outside of Section Territory

Harry Brinkley Anderson, Marshall C. Armstrong, Alfred Benton Blythe, Robert Cohen, Kenneth R. Herrmann, John W. Skopec, Harold B. Stallings, Robert Noel Stevenson, Bryon C. Thomson, Peter Jacobus Visser.

Foreign

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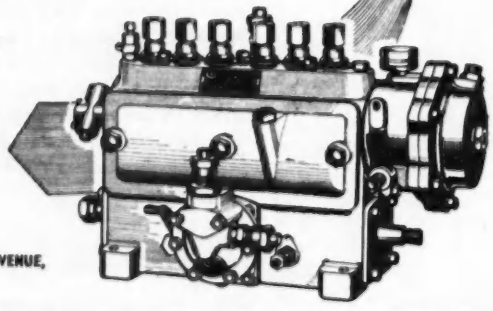

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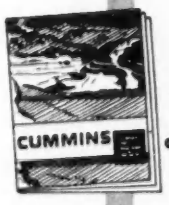

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R/M
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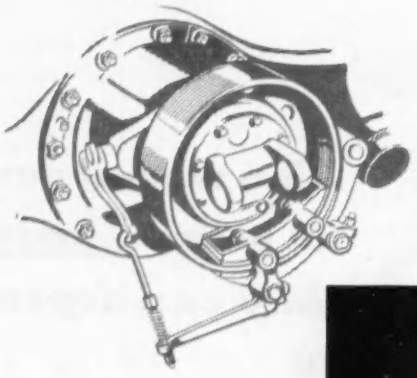
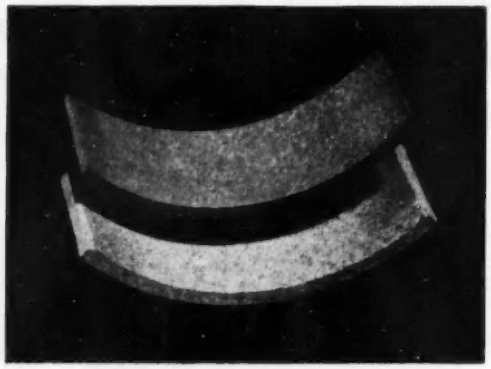
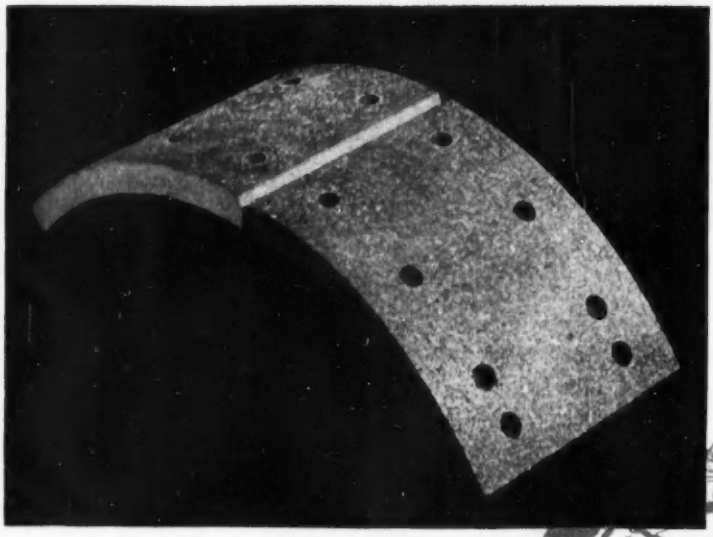
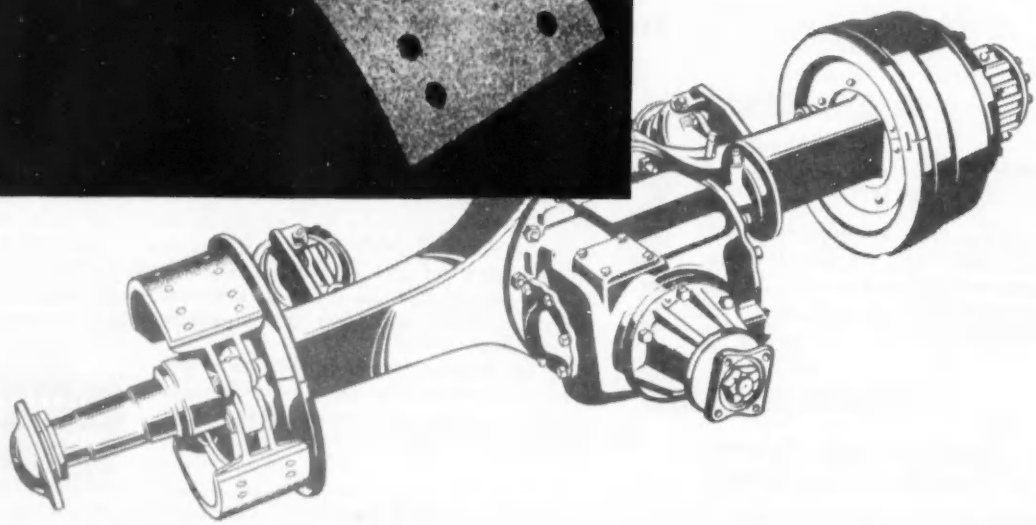


This handbrake is a marvel of mechanical simplicity. It gives maximum efficiency with minimum maintenance. The two opposing brake shoes are lined with an R/M high friction lining, M-2761, and an R/M low friction lining, M-2541. The combination means dependability over a long period of time.





This wheel brake is part of an axle unit designed to be the lowest in weight available today in relation to load-carrying capacity. Two entirely different types of ¾" brake blocks made by R/M are combined to provide the safe, efficient stopping every operator wants.

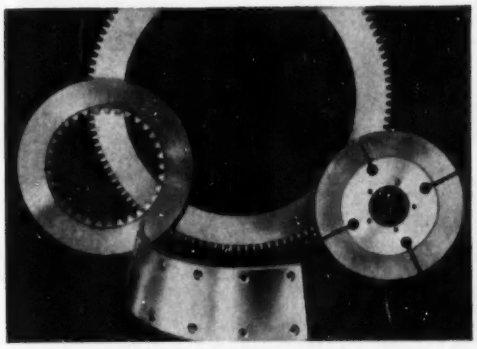


THE TRADE-MARK THAT SPELLS PROGRESS IN FRICTION MATERIAL DEVELOPMENT!

Ever since the day, more than 50 years ago, that R/M developed the first asbestos brake lining, Raybestos-Manhattan has set the pace for automotive friction materials. Year after year it has anticipated engineering needs and been ready with advanced-design materials. Its leadership today is evidenced by the fact that more trucks, buses and cars use R/M brake linings, brake blocks, clutch facings and automatic transmission parts than any other make.

But the automotive industry is only an example of the fields which the R/M Corporation serves in a large way. Equipment manufacturers in general count on R/M to meet every advance in their progress. It is true of the makers of construction equipment, of mining equipment, of office equipment, etc.

R/M achieves its outstanding results by working with countless combinations of different types of friction materials . . . including woven and molded asbestos, semimetallic materials, and sintered metal parts. If you have a friction material problem, call in your R/M representative. Get the advantage of R/M's years of know-how, its seven great plants, their research departments and their testing laboratories.



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Write for your copy of the R/M Engineering Bulletin. It describes and illustrates many R/M friction materials for aviation, agriculture, the automotive industry and others.

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R M

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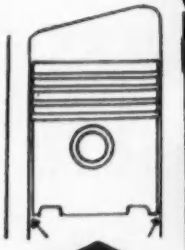

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UNIFORM EFFECTIVE SKIRT CLEARANCE AT ALL TEMPERATURES

ZOLLNER CLEAR-O-MATIC* PISTONS

*T. M. Reg. Pat. App. For

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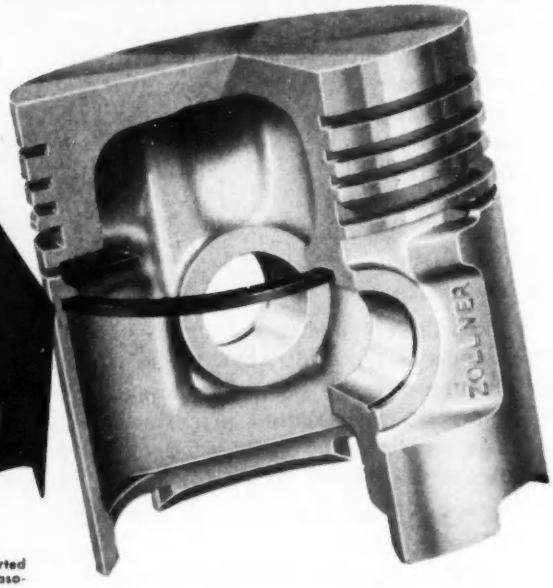
Anchored only at pin bosses and cast in positive contact with I. D. of piston skirt
Controls Clearance Automatically



Design adaptable to full skirted or slipper-type pistons for gasoline engines for every purpose.

Heralded by engine builders everywhere as sensational, the Zollner developed CLEAR-O-MATIC Piston *reduces required clearance to less than .001 with positive uniformity of skirt bearing under all temperatures.* The steel tension member incorporates in the aluminum piston the same effective expansion as the ferrous cylinder itself. Spectacular in performance, the CLEAR-O-MATIC Piston results in a *quiet engine with no cold slap, reduced friction without loss of durability or heat conductivity.* We suggest an immediate test of these advantages in your engine.

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2. Effective expansion identical with ferrous cylinder.
3. Steel tension member, with same effective expansion as cylinder, maintains uniform skirt clearance through entire temperature range.
4. Normal diametric clearance usually less than .001 with uniform skirt bearing.
5. Durability and conductivity comparable to heavy duty design.

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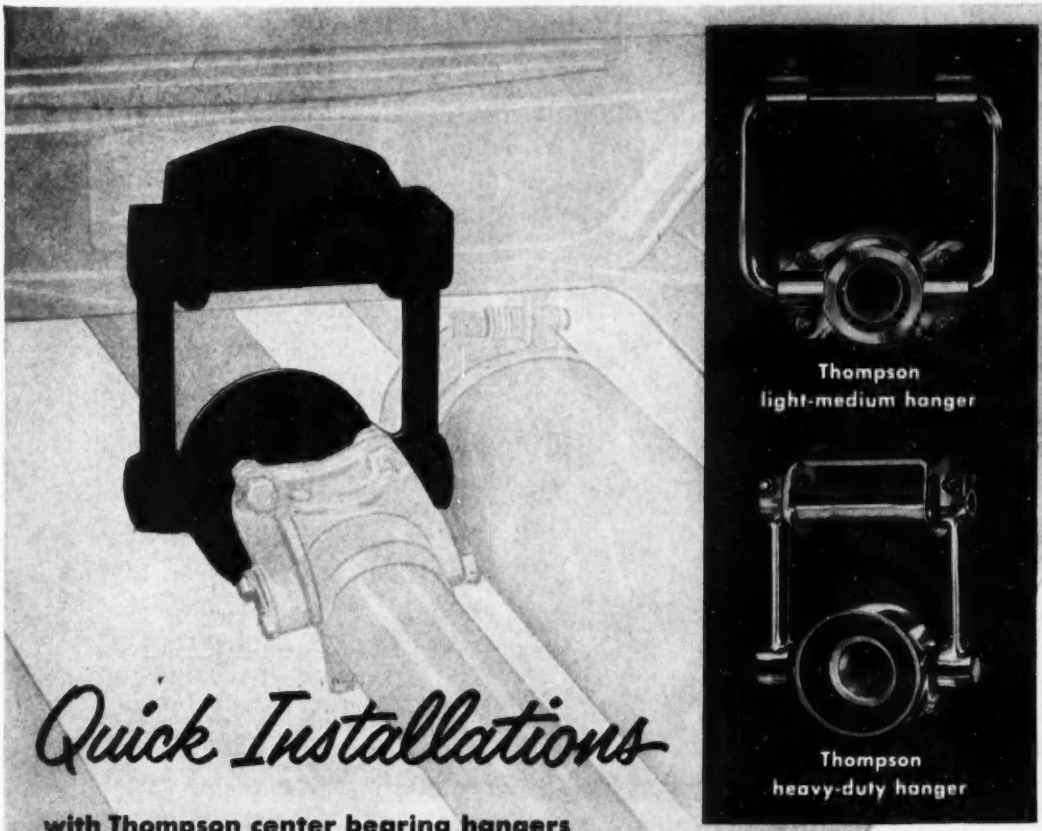

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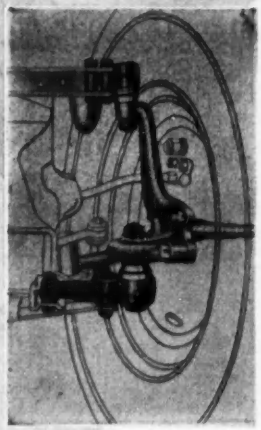
Investigate this Thompson truck development. Let us show you how it will cut production and distribution costs, improve "in service" operation. Write to Thompson Products, Inc., 7881 Conant Avenue, Detroit, Michigan, or telephone WA 1-5010.



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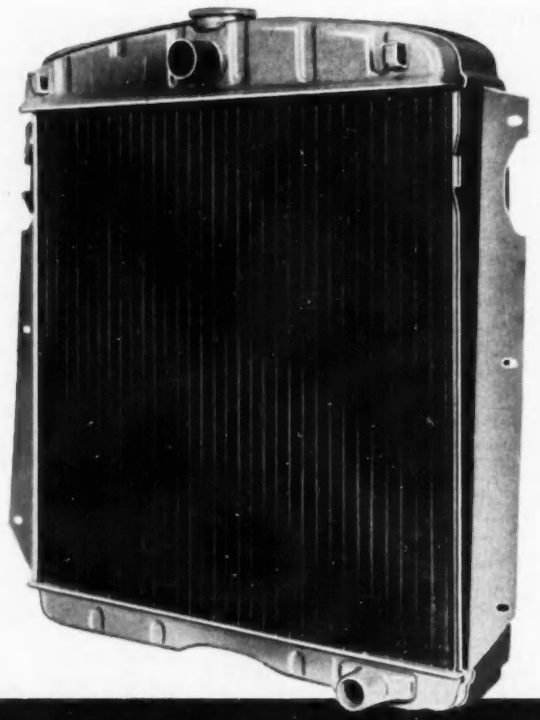

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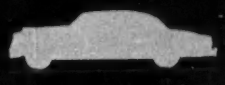

Now in production on 10 passenger cars,
and used by
other manufacturers
for transmission, lubrication,
and hydraulic control

For your new models—advanced low-cost design,
reduced horsepower requirement, new systems.

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For Piston rings to meet every requirement
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FOR YOUR CAR

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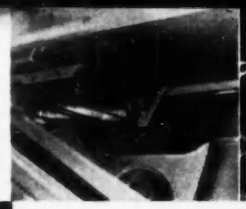
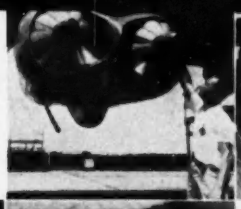


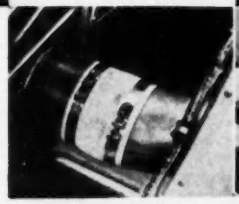
Each of the 12 vents on the B-36 are wrapped with resistance wire and Silastic R Tape to keep ice from plugging oil vent lines.



Thin layers of Silastic insulate bare resistance wire inside jet intake door panels; conduct deicing heat evenly and rapidly to panel surfaces.

More than 180 limit switches on the B-36 are protected with Silastic boots to assure reliable operation at temperatures ranging from —100° to 170°F.

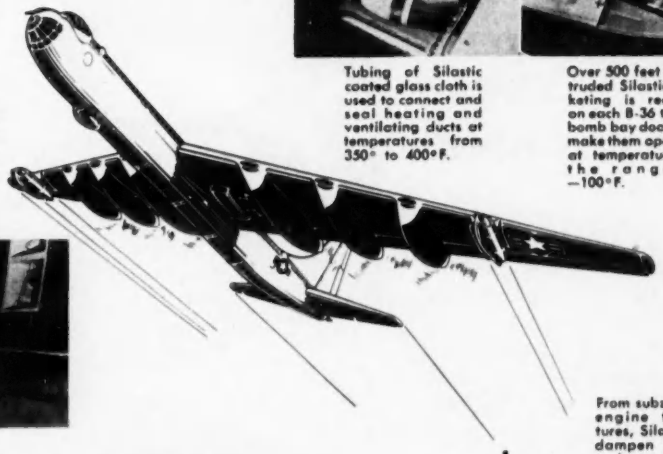
Silastic-coated glass cloth gaskets on the rockerboxes of the P & W engines give long service in contact with oil at temperatures up to 450°F.



Nose turrets are sealed with two 56-inch lengths of cloth-wrapped, sponged Silastic tubing.

Over 300 Silastic flange gaskets in each B-36 seal hot air system at temperatures as high as 400°F.

"Orlon" wrapped, sponged Silastic seals prevent air turbulence between flap and engine nacelle; last 10 times as long as materials previously used.

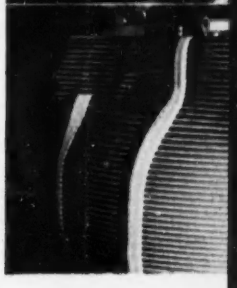


Tubing of Silastic coated glass cloth is used to connect and seal heating and ventilating ducts at temperatures from 350° to 400°F.

Over 500 feet of extruded Silastic gasketing is required on each B-36 to seal bomb bay doors and make them operable at temperatures in the range of —100°F.

Ninety feet of cloth-wrapped, sponged Silastic is used to prevent turbulence and short circuiting of air between leading edge of the flaps and trailing edges of the wings.

From subzero to hot engine temperatures, Silastic strips dampen vibration and prevent breakage of cooling fins on aircraft engine cylinders.



Performance proves...

SILASTIC* works

where other materials fail!

Extreme temperature Silastic stocks are the only rubbery materials that retain their resilience after long exposure to temperatures from —100° to 350°F or after repeated short term exposure to temperatures from —130° to over 500°F. That's why Silastic parts have proved so effective in actual service on the high flying Convair B-36.

The usefulness of rubberlike materials at extremely low temperatures can be established by the recently developed Gehman Flex Test Method (ASTM D1053-52T). Values measured according to this method on an extreme temperature Silastic and a synthetic organic rubber especially compounded for a low temperature service are plotted in Figure 1.

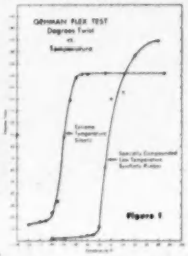


Figure 1

You will note that Silastic does not begin to stiffen until it reaches —50°F, and that it still has a twist value of 13.5 degrees at —130°F. The special low temperature organic rubber loses resilience at +50°F, and will take a twist of only 12 degrees at —22°F.

The usefulness of Silastic on the B-36 is increased by its excellent resistance to oxidation, weathering and to a variety of hot oils. In electrical applications, Silastic stocks are unique even among silicone rubbers for low water absorption and excellent dielectric properties, plus high physical strength.

That kind of performance is typical of Silastic, the Dow Corning silicone rubber. When you need flexibility or good dielectric properties in a resilient material that will withstand years of weathering or long exposure to temperatures far above and below the limits of ordinary rubbers, specify Silastic.

*T. M. REG. U. S. PAT. OFF.

MAIL COUPON TODAY FOR DATA ON THE PROPERTIES OF SILASTIC.

DOW CORNING CORPORATION, Dept. V-8, Midland, Michigan

Please send me:

- ☐ Silastic Facts 10a, properties and applications of Silastic stocks and pastes.
- ☐ List of Silastic Fabricators.
- ☐ "What's A Silicone?", new 32-page booklet on silicone products and applications.

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Midland, Michigan

These and other B-36 applications for Silastic are more fully described in the March 30, 1953 issue of Aviation Week.

In Canada: Fiberglas Canada Ltd., Toronto In Great Britain: Midland Silicones Ltd., London

Where weight and space are critical

New miniature transducers expand the scope of dynamic recording systems

A BASIC PROBLEM in transducer design is reduction of size to a point where characteristics of the device under test are not affected. Two new transducers developed by Consolidated combine unusually small size and weight with operating characteristics fully comparable to previous larger instruments.

The 4-310 Pressure Pickup features a direct-sensing diaphragm and is mountable flush with any surface to avoid both volume changes in the pressure chamber and spurious turbulence patterns. It is valuable for aerodynamic pressure surveys and other high-frequency liquid or gaseous pressure measurements.

The new 4-118 Velocity Pickup is usable at high temperatures in any plane of orientation. Its output equals instruments many times its size and weight, yet it has no loading effect on structures being tested. Applications include turbine, supercharger, rocket and jet engine vibration studies.

4-310 pressure pickup

Sensitivity: 4 mv/v of applied excitation.

Ranges: 5, 15, 50, 150 psi.

Temperature range: —100°F to +250°F.

Sensitive element: 350-ohm, 4-arm resistance bridge.

Excitation: ac or dc.

Linearity and hysteresis: excellent characteristics.

Acceleration response, zero and sensitivity drift: negligible.

Versatility: usable for liquid or gas measurements.

Size: diaphragm diameter ½", length ⅝".

Complete specifications in Bulletin 1534A-X4.

4-118 velocity pickup

Output: 100 mv/in./sec. @ 250 cps.

Frequency range: linear ±10% from 50 to 500 cps over range of —65°F to +500°F.

Amplitude limits: to 0.12" peak-to-peak.

Transverse sensitivity: negligible.

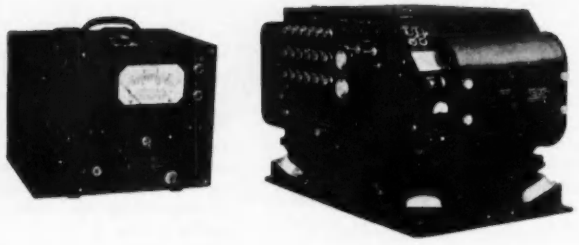
Sensitive element: self-generating, nominal 700-ohm dc coil resistance.

Total weight: 1.3 ounces.

Size: ¾" diameter, height 1".

Complete description and specifications in Bulletin 1535-X4.

Vibration can be easily, precisely measured and monitored by combining the Velocity Pickup with Consolidated's Vibration Meters, described in Bulletin 1505B.



Transient or high-frequency vibrations and pressure changes can be recorded for detailed study with Consolidated's Recording Oscillographs. Send for Bulletin 1500B.

Consolidated Engineering
CORPORATION
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Sales and Service through **CEC INSTRUMENTS, INC.,** *a subsidiary with offices in: Pasadena, New York, Chicago, Washington, D. C., Philadelphia, Dallas.*

analytical instruments for science and industry

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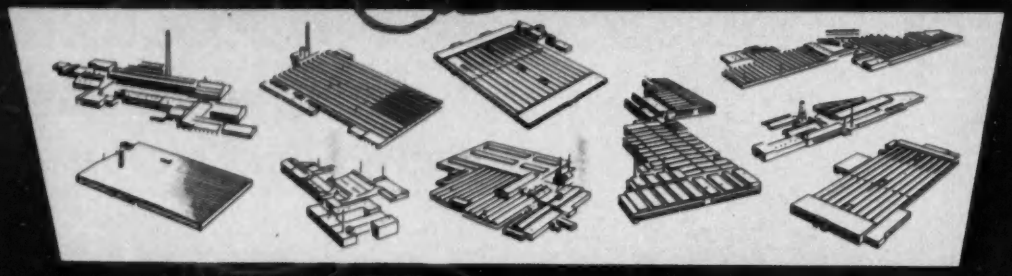
Consolidated's new miniature transducers, among the smallest ever designed for pressure and vibration measurement, are adaptable to the most exacting mounting requirements.

the desire to serve

The *will* to serve is a Spicer tradition backed by nearly 50 years of outstanding achievement. It has been the impetus behind the wide range of Spicer accomplishments, that have done so much to make automotive vehicles so efficient.



the ability to serve

The Spicer *will* . . . plus Spicer skill and resources . . . form a strong *ability* team. Ten modern plants, geared to modern manufacturing tempo, are producing equipment that is the Standard of the Industry. We are prepared to design, develop, engineer and manufacture . . . with a high degree of excellence . . . your special needs in power transmission units.

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ONLY 2 MOVING PARTS

do the pumping in a Pesco Hydraulic Pump

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- ***reliability—less chance of pump malfunction***
- ***less maintenance***
- ***less cost for overhaul***
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Add *Pesco Simplicity of Design* to Pesco's *exclusive*, patented "Pressure Loading" principle, which results in volumetric efficiencies up to 97% and torque efficiencies up to 90%, and you have two important reasons why so many industrial and aircraft manufacturers have standardized on Pesco pumps.

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Ryan's electrical resistance welding facilities—the largest and most modern in the aircraft industry—are typical of the fine production equipment available. Ryan pioneered in this field while searching for a fast, clean, weightless way to fuse heat-resistant metals. For high-temperature jet, piston and rocket engine components, the aircraft and aircraft engine industry has learned to RELY ON RYAN.

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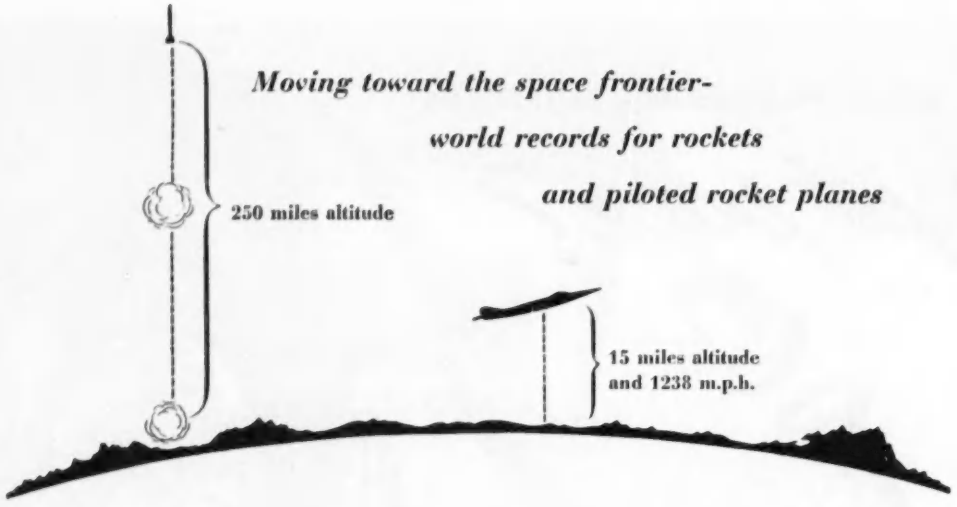


Moving toward the space frontier-

world records for rockets

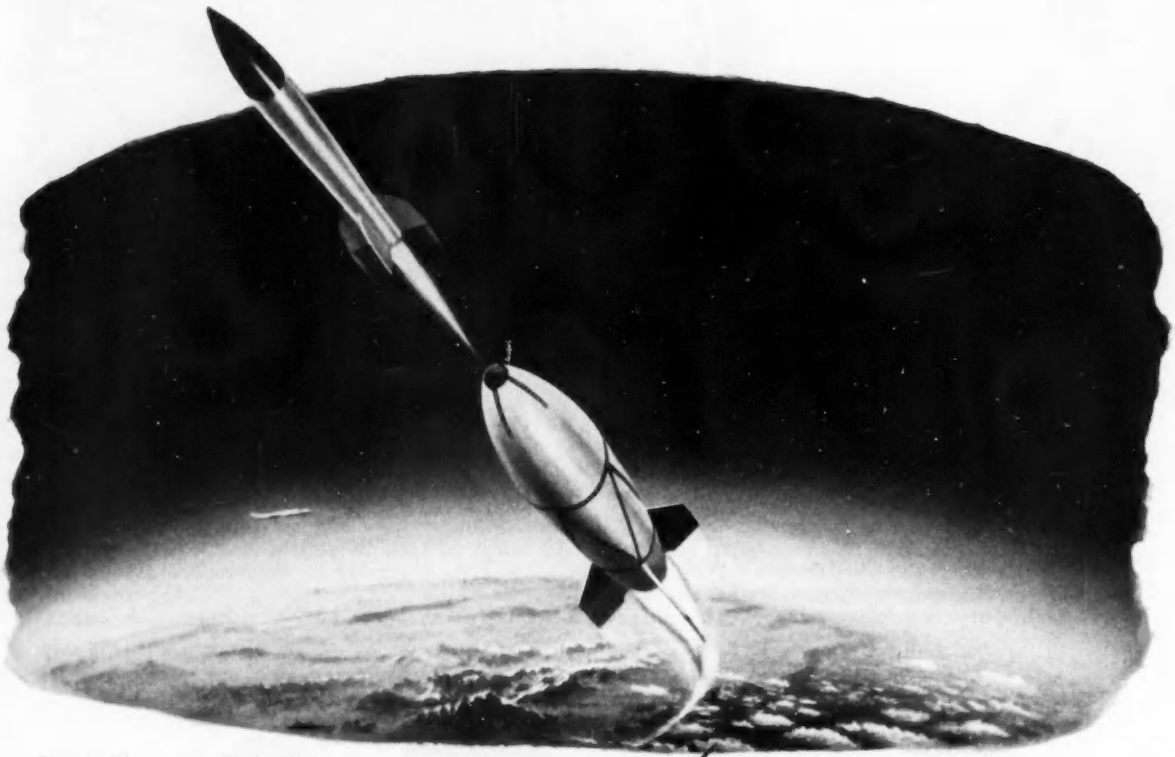
and piloted rocket planes

—the Douglas Skyrocket and Wac-Corporal

How soon will man cross the Space Frontier? Already, Douglas-built planes, rockets, and missiles—including the Wac-Corporal and D-558-2 Skyrocket—have probed at its fringes.

In a record climb, the Douglas D-558-2 reached an altitude where its pilot was *weightless*, as in a flight through space, while the Wac rocket, set in the nose of the V-2, travelled one-quarter of the way to the proposed orbit of a man-made satellite. Most important, both records came during *normal research*—planned to keep the United States and its Armed Forces out in front in the fields of guided missiles and supersonic aircraft.

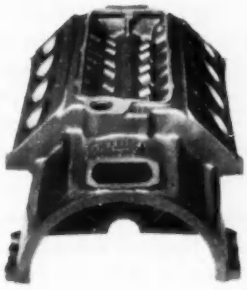
Performance of Skyrocket and Wac-Corporal is proof of Douglas leadership in all phases of flight. *Farther and faster with a bigger payload* is the basic rule of Douglas design.



Army's Wac shown leaving V-2

Depend on *DOUGLAS* **First in Aviation**

They're pouring horsepower into ***smaller*** *packages*



Stallions of industry, harnessed to pull a mighty load . . . that's horsepower in a V-type engine. With this unique design, more power is concentrated in less space . . . put to work with greater efficiency. Almost 40 years ago Campbell, Wyant and Cannon poured its first V-shaped cylinder block – helped give heart to this now famous power plant. Since then advances have been many, with CWC sparking the way – *building more V-type cylinder blocks than any other independent contract foundry.* Teaming its long experience with a constant search for the new and better, CWC gives V-type engine builders cylinder blocks that possess finest physical properties . . . that lengthen engine life, step-up engine performance. Next time you think of castings . . . think of CWC. Learn what a difference the *right* casting can mean to your product.

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Since 1908

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Important at the retail level, too!

DELCO Hydraulic Shock Absorbers

"This car has Delco shock absorbers" is a statement often made by salesmen for its favorable effect on prospective buyers. For more than 24 years a majority of the nation's car owners have been riding on Delco shocks. These people have experienced increased riding comfort, on every kind of road, with every improvement Delco has made.

The car owner may not understand the full significance of Delco's engineering improvements, but experience has taught him that if he has Delco shock absorbers he has the best. For full information on its complete line of shock absorbers, call Delco Products, Division of General Motors Corporation, Dayton, Ohio.

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Is a Prime Factor in Every Automobile Sale!

Engine performance not only influences *today's* customers, it also builds a reputation which effects *future* sales. Thus, it is doubly important to specify engine components that will maintain your standards of quality and service. In carburetors that means Stromberg.

Exclusive design features, and mechanical simplicity have made Stromberg* Carburetors famous for *lasting performance*. Judge on the basis of *long-range economy* and you will agree—Stromberg Carburetors are the logical choice.

*REG. U. S. PAT. OFF.

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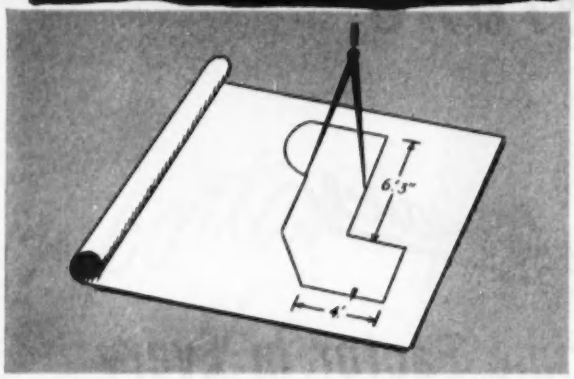
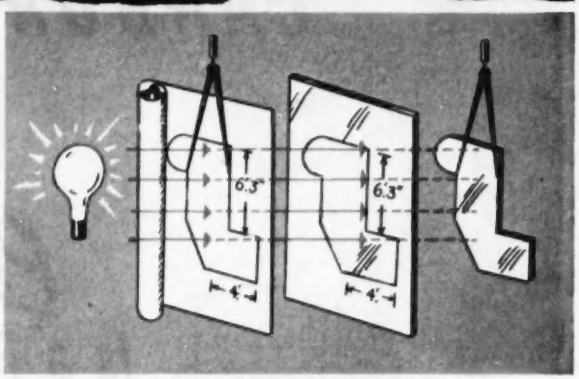
STABILENE*

GLASS TRACING CLOTH



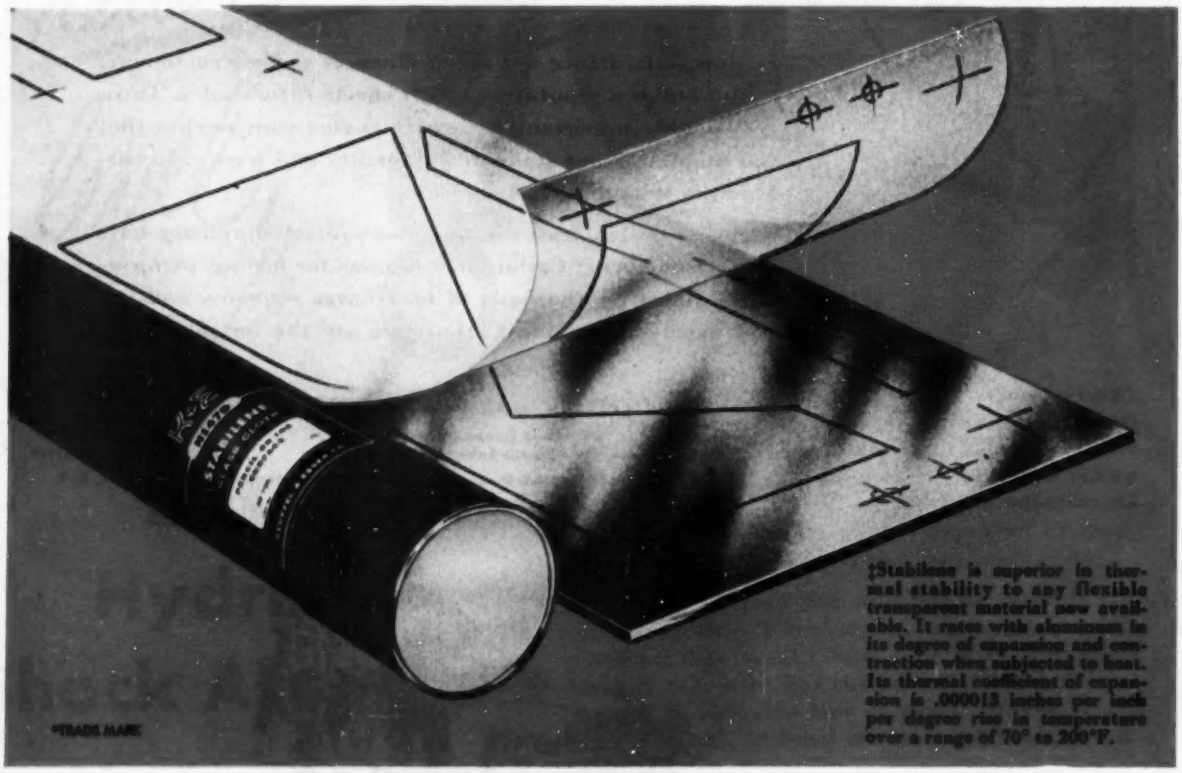


DIMENSIONALLY STABLE† TRACING CLOTH: Stabilene—first nationally introduced by K&E—is a new kind of tracing cloth—a *woven glass* cloth with a high degree of *transparency*. It is specially impregnated to provide an excellent drawing surface for pencil or ink.

Because Stabilene is both dimensionally stable and transparent, you can reproduce from Stabilene right on tool materials.

"DRAW IT *ONCE*": Tool designs are drawn *only once*—full scale on Stabilene—then reproduced by contact printing on tool material which has been sensitized with a reproduction solution.

Preliminary dimensional drawings on tracing paper or cloth are eliminated altogether. The original drawings on dimensionally stable Stabilene are the *only* drawings required from drafting room through tool production.



*TRADE MARK

†Stabilene is superior in thermal stability to any flexible transparent material now available. It rates with aluminum in its degree of expansion and contraction when subjected to heat. Its thermal coefficient of expansion is .000013 inches per inch per degree rise in temperature over a range of 70° to 200°F.

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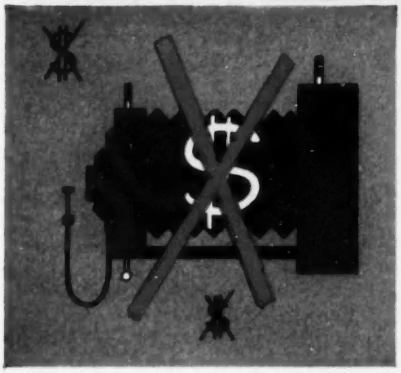
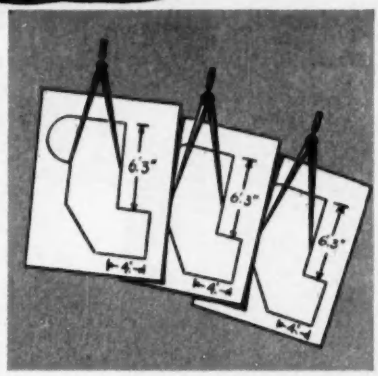
The Right Angle



REVOLUTIONIZES PRODUCTION AND COSTS: Eliminates the need for shop layouts, camera photography, hand-scribing, and other methods calling for expensive equipment and highly trained personnel.

If a template is damaged or extra templates are needed new ones can be made from the original Stabilene drawing . . . quickly, easily, and inexpensively.



"DUPLICATE ORIGINALS" FROM STABILENE: Stabilene, itself sensitized for reproduction, can be used for dimensionally stable "duplicate originals." Such reproductions made on Stabilene are easily shipped to sub-contractors in lightweight rolls. "Duplicate originals" can also be used as the basis for design changes, new drawings, or composite drawings.

Stabilene has cut costs for the aircraft industry, for instance, by eliminating many laborious steps once essential to the production of jigs, fixtures and dies, and other tools.

Stabilene is used by oil and utility companies, as well as by government departments for mapping and plane table work. Stabilene's dimensional stability is of vital importance in all these functions. For optical comparator work, the dimensional stability of Stabilene Glass Tracing Cloth makes it as accurate as the glass screen itself. Its transparency, too, is an essential feature for this work.

Stabilene has done much for others . . . think about what it might do for you . . . in cutting costs and speeding production.

We will gladly advise you about the application of Stabilene and help you get started. K&E can also make Stabilene reproductions for you. Write Keuffel & Esser Co., Hoboken, N. J. or ask your nearest K&E Branch or Distributor.

Save time, trouble and eyesight with a K&E PARAGON† Drafting Machine. You control your calibrated straight edge with a light touch of one hand, for parallel lines and lines at any angle.

Make your lettering letter-perfect and save wear and tear on your nerves by using a LEROY† lettering outfit. Template grooves guide your pen so the finished result looks like printers' type, and the whole process is relaxing. There's a wide choice of sizes, styles and symbols.

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Need low starting friction and long bearing life?

here's how leading manufacturers of business machines get them with NEEDLE BEARINGS

Torrington Needle Bearings are essential design features of many business machines because of their low starting and running friction, their long trouble-free service.

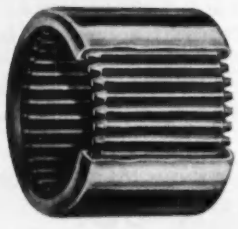
They have been *performance-proved* by years of day-in and day-out service on such machines as electric typewriters, addressing and duplicating machines, accounting machines, rotary card file systems, etc.

On the conveyor rolls, sprockets, gears, tape and feed roll shafts of duplicators, for example, Needle Bearings help reduce power requirements and keep motor size to a minimum. The Needle Bearing's turned-in outer lips effectively retain lubricants to keep these precision machines running for long periods without servicing.

The Torrington Needle Bearing has become "standard equipment" on countless products throughout industry since its introduction nearly twenty years ago. Its small size and infrequent lubrication needs are of great advantage in compact, tightly encased designs.

Perhaps the Needle Bearing can solve your anti-friction problems. Our engineers will be glad to work them out with you.

THE TORRINGTON COMPANY
Torrington, Conn., South Bend 21, Ind.



TORRINGTON NEEDLE BEARINGS

Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers

Trade-marks of some of the business machine manufacturers whose products enjoy the benefits of Needle Bearings.

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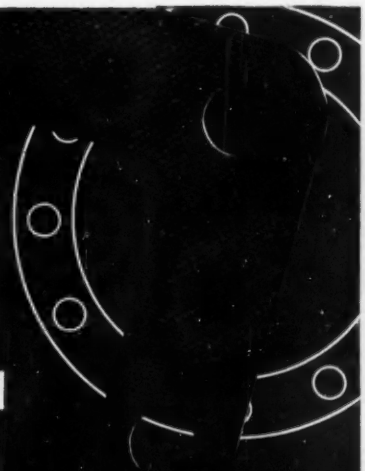
ASBESTOPRENE #233

fills the gap in "Soft" Automotive Gasket Material



New Asbestos-Neoprene Sheet Packing is Both Compressible and Heat Resistant

Where heretofore you've had to sacrifice compressibility or heat resistance in standard sealing materials for oil, greases, water, gasoline, etc., now ASBESTOPRENE #233 combines these properties to a very useful and satisfactory degree. In addition, ASBESTOPRENE #233 shows marked improvement in other characteristics over the usual compromise specifications such as gelatin-treated paper or cork. It is better in corrosion and fungus resistance . . . in torque loss . . . and dimensional stability.

A Victor Quality Product — in Sheets or Finished Gaskets

Base material of ASBESTOPRENE #233 is a selected long asbestos fiber. It is felted and bonded in complete homogeneity by a beater impregnation process with a new heat-and-oil resisting neoprene latex.

Victor die-cutting techniques assure accurate manufacture, fast delivery, and important economies on all gasket orders whether large or small production runs. ASBESTOPRENE #233 is also available in sheets.

Complete Specifications and Sample Sent on Request

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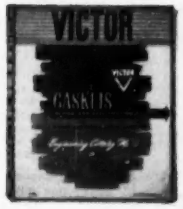

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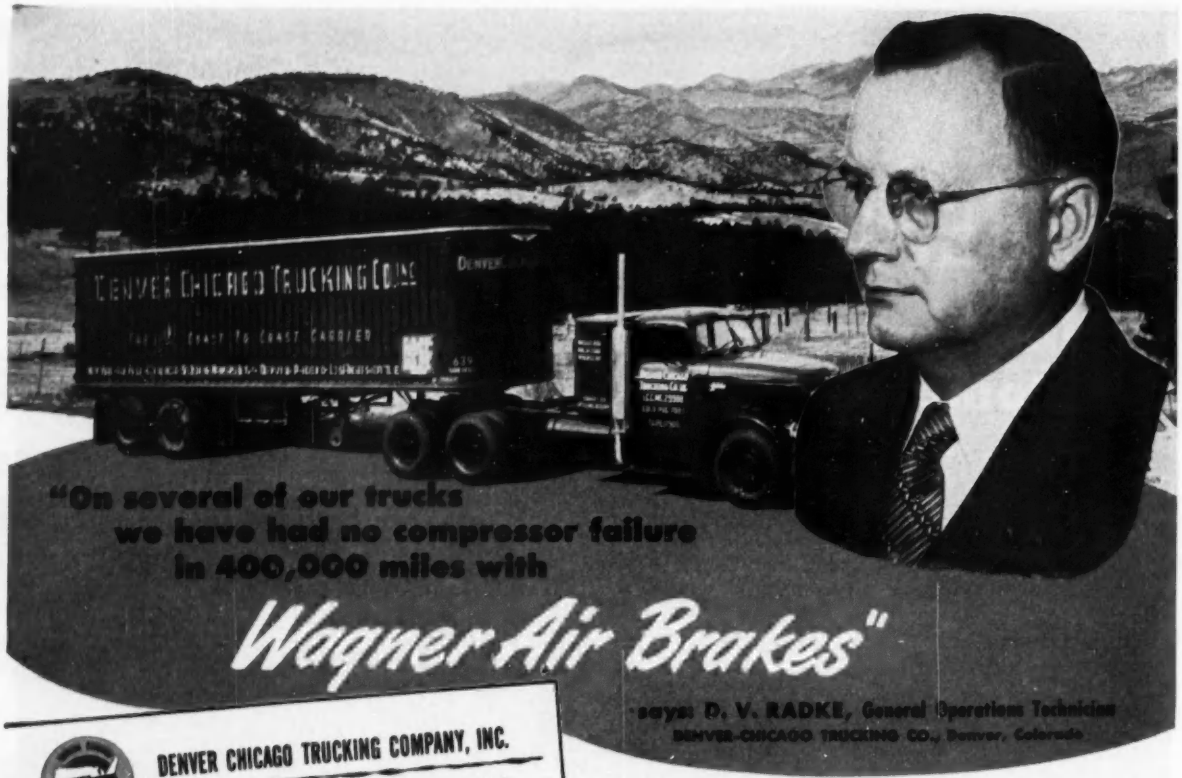
DENVER CHICAGO TRUCKING CO. INC.
DENVER
"On several of our trucks
we have had no compressor failure
in 400,000 miles with
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says: D. V. RADKE, General Operations Technician
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TERMINALS

Wagner Electric Corporation
6400 Plymouth Avenue
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Gentlemen:

We, here at Denver-Chicago Trucking Company, Inc., take great pride in the fact that we are the only coast-to-coast carrier in the United States. In order to maintain our standards of leadership we have come to realize that service is the very essence of our business; it is the keystone which means failure or success in the motor transportation industry. In Denver-Chicago's case, it has meant success.

Part of the service we render customers is making sure we live up to our responsibility of providing our drivers with trucks that are safe to operate, dependable in performance, and will take the punishment of coast-to-coast driving. I can truthfully say that our trucks equipped with Wagner Air Brake Systems provide ample braking power to safely bring these units to a safe stop at all times on the road.

I have been told by our Regional Managers that Wagner Air Brakes are economical to operate and require very little repair and replacement of parts. The Wagner Rotary Air Compressor is easy to install, quiet in operation, and provides ample air. On several of our trucks we have had no compressor failure in 400,000 miles with Wagner Air Brakes.

For these reasons, we specify Wagner Air Brakes when we order new equipment for Denver-Chicago.

Very sincerely yours,

D. V. Radke
General Operations Technician

Time and again, fleet operators like Mr. Radke have proven for themselves that Wagner Air Brake Systems keep costly maintenance expenses at a minimum and help meet on-the-road schedules which mean increased profits at the end of the year. Many agree that even after *years* of service, units equipped with Wagner Air Brake Systems never have compressor failure or require need for exchange. This outstanding record of proven dependability and service is largely due to the Wagner Rotary Air Compressor—the compressor that assures you an adequate supply of air at all times because it has a faster air recovery.

Give the vehicles you manufacture added brake economy and safety by including Wagner Air Brakes as standard equipment. Our engineers will gladly work with you and recommend the Wagner Air Brake System best suited to your particular requirements. Catalog KU-201 gives full information. Write for your copy today.

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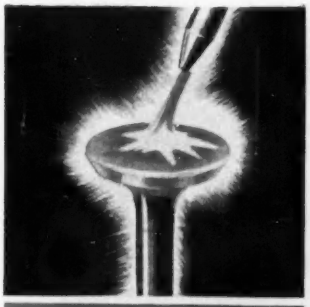

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These facilities ...this special know-how

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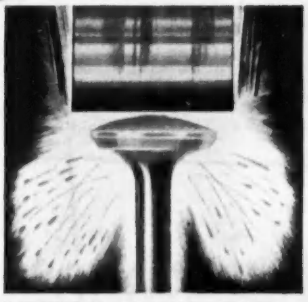

FORGING TOUGH ALLOYS

Every day the Valve Division is welding thousands of pounds of high-alloy coatings to unusual Thompson-developed alloys to give internal-combustion engine valves added life under super-severe service.

We also insert highly-combustible metallic sodium into hollow valve stems to make engine valves run cooler and last longer.

The Valve Division also knows plenty about forging and finishing extra-tough alloys to precision limits.

If you have out-of-the-ordinary production problems, you'll want to know more about Thompson know-how and facilities. And, if you have ideas about how we can help on new projects, we'd like to talk them over with you.

VALVE DIVISION

Thompson Products, Inc.

DEPARTMENT VS-8 • CLEVELAND 17, OHIO

This Size . . . . ➧

or This Size . . . . ➧

with all "kinds of sizes" in between

SKF's wide range of bearing types and sizes, plus helpful SKF engineering cooperation, makes it possible for you to select the bearing whose characteristics make it the best bearing choice for your particular application.

SELF-ALIGNING BALL BEARINGS

Compensate for angular misalignment resulting from faulty mounting, shaft deflection or distortion of the foundation. For radial loads and moderate thrust loads in either direction.

SPHERICAL ROLLER BEARINGS

Unexcelled for capacity. Inherently self-aligning. The full capacity of the bearing is always available for useful work. Will carry substantial thrust load in either direction.

DOUBLE-ROW DEEP GROOVE BALL BEARINGS

Embody the same design principle as the single-row type, but have lower axial displacement and substantial thrust capacity in either direction. Have very high radial capacity.

SINGLE-ROW DEEP GROOVE BALL BEARINGS

Sustain, in addition to radial load, substantial thrust load in either direction even at high speeds. Available with famous Fairprene Red Seals which keep dirt out and lubricant in. Also with any combination of Red Seals, shields, and snap-rings. Furnished in standard or precision tolerances.

ANGULAR CONTACT BALL BEARINGS

Support heavy thrust load in one direction, sometimes combined with moderate radial load. Can be mounted singly or in tandem for constant thrust load in one direction; also in pairs, face-to-face or back-to-back, for combined thrust and radial loads.

CYLINDRICAL ROLLER BEARINGS

Very high radial capacity and low friction which permits high-speed operation. Easy to dismount, even when both rings are mounted with a tight fit.

BALL THRUST BEARINGS

For pure thrust load in one direction only. Not self-aligning. The load line through the balls is parallel to the shaft axis, resulting in high thrust capacity and minimum axial deflection.

SPHERICAL ROLLER THRUST BEARINGS

For heavy thrust loads, or combined loads which are predominantly thrust, at high speeds on vertical or horizontal shafts. Fully self-aligning.

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– manufacturers of **SKF** *and* HESS-BRIGHT *bearings.*

7388

Alcoa Research solves

the case of the broken fan blades

When the high incidence of breakage in a special cast aluminum cooling fan created a critical problem, technicians laid the blame to high rotational speeds.

Alcoa engineers thought otherwise. Into our 80,000 rpm "whirl pit" went a sample fan, covered with a brittle lacquer that shows when it cracks where stresses occur. Stopping at intervals for inspection and photographs, speeds were stepped up past the operating maximum of 5,500 rpm, past the safety margin at 6,500 rpm. Far above that speed, the fan shattered.

Out of these tests came proof that the true cause of failure was vibration fatigue at the root of the blade, excited by extraneous forces. Redesigning to relieve stress concentration permitted continued use of cast aluminum with attendant savings in production costs.

Alcoa testing facilities like the "whirl pit" are a regular part of our service. You can bring them to bear on your problem by calling your Alcoa sales engineer, who is listed in the yellow pages of your telephone directory.

Alcoa Aluminum

ALUMINUM COMPANY OF AMERICA

ALUMINUM COMPANY OF AMERICA
1844-H Alcoa Building
Pittsburgh 19, Pa.

Please send me a copy of your "Road Map to a Better Product" outlining Alcoa's research and development facilities.

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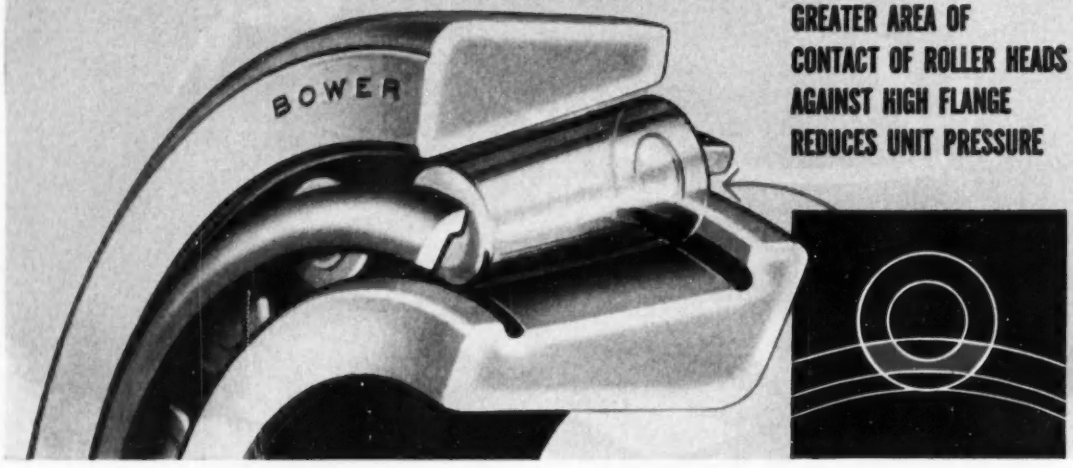
Bower spher-o-honed design increases bearing life



Bower engineers have incorporated many basic refinements into the design of Bower tapered roller bearings which cut maintenance to a bare minimum—increase efficiency. One of the most important of these is the *exclusive* feature illustrated above. Note that the flange at the large end of the cone is *higher*—providing a greater contact area for the roller heads. This greatly reduces wear, improves roller alignment and minimizes resultant "end play". Also note the larger oil groove, providing positive lubrication to the roller heads.

Other important Bower features which increase bearing life and dependability are generated spherical rollheads, and smooth, precision-honed races. And Bower bearings are known throughout industry for materials and workmanship of highest quality.

Whether your product is in full production or still in the planning stage, you'll be wise to call in a Bower engineer now. He'll show you a wide range of sizes and types to fit any application.

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BOWER

ROLLER BEARINGS

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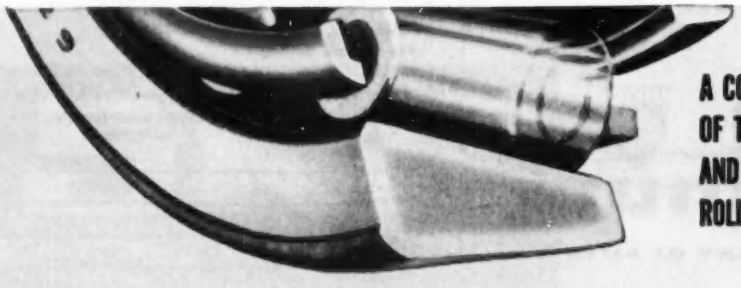

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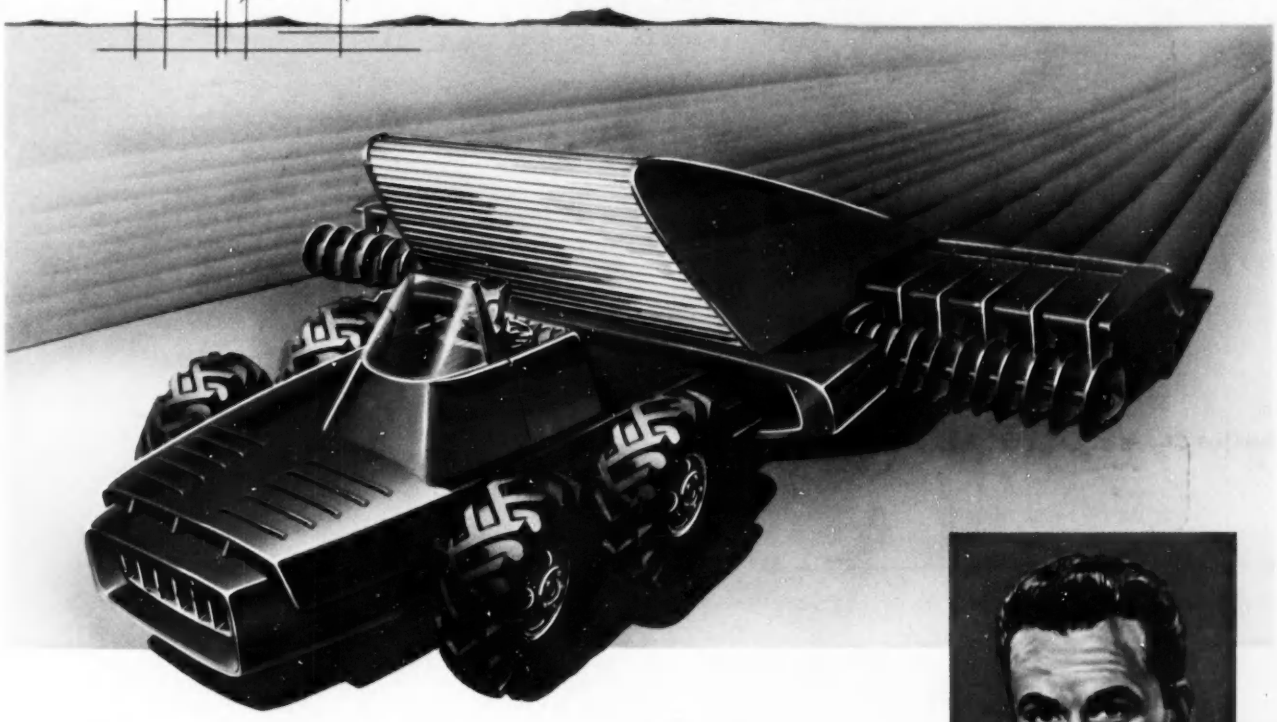
ROLLER BEARINGS

"Processing the soil with chemical additives and conditioners will ultimately revolutionize farming. We illustrate a diesel unit for larger farming operations, designed for the threefold purpose of turning the soil, blending in the additives and planting the grain. "The articulated propelling unit also drives the high speed rotary discs or cutters, and the mixing stage which follows. Chemicals from the hopper are introduced into the aggregate as it is mechanically broken up and sized. The third stage is an integral seed drill."

. . . CARL OTTO



"Revive lagging markets, reach new buyers with robust color styling and functional design"

. . . says Carl Otto, New York Industrial Designer

"WHEN markets lag and buyers lose the impulse to buy, just plain good salesmanship would never be enough to keep America's industrial giant humming," says Carl Otto, New York Industrial Designer.

"Certainly we must sell, but we must also direct the full strength of our imaginations toward constantly restyling and improving the things we make to sell. In this we cannot rest nor relax.

"We must keep alive the impulse to buy . . . through a program of powerful design and color styling, and by building into our products greater benefits for the user! *This we must do with regularity and consistency!*"

KEEP ALIVE THE IMPULSE TO BUY YOUR PRODUCTS . . . with the help of a *planned* design and color styling program! Industrial designers and automotive or industrial color stylists are invited to make the most of color by availing themselves of the consulting services of the Rinshed-Mason color styling section. *Ask us for a study in color . . . applied to your product!*

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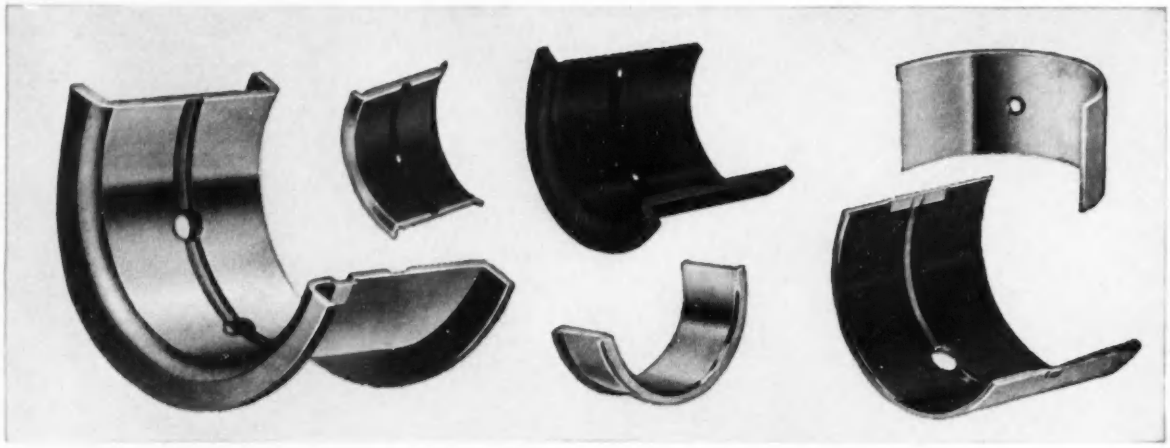
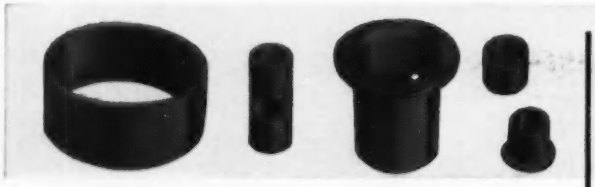
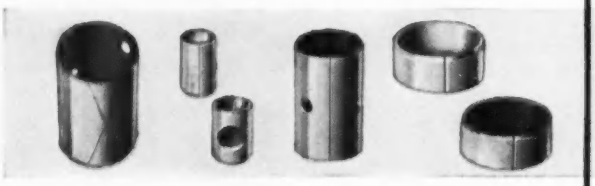


Sleeve bearings in a wide variety of designs and sizes

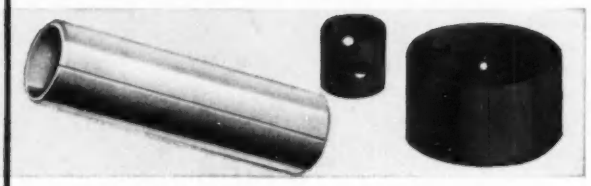


Cast bronze bushings

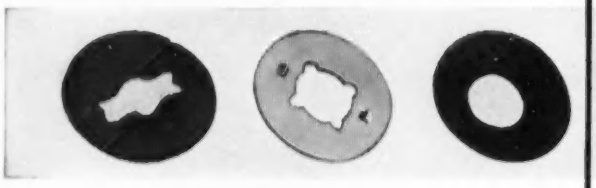
Precision bronze parts



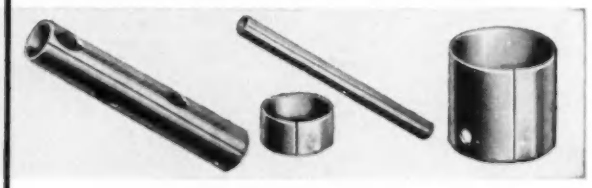
Bi-metal split bushings



Rolled split bushings



Washers



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What every Automobile man should know about Power Steering

The fastest-growing innovation in automotive history is Power Steering—and the leader in Power Steering is SAGINAW, world's largest producer of steering gears. Saginaw Power Steering is now available on all General Motors cars and three other well-known makes. Nearly 600,000 new cars have been equipped with it—more than all other types combined. So naturally, many people wonder:

6. HOW DOES SAGINAW POWER STEERING OPERATE?

Basically, it is simply a highly-efficient Recirculating Ball Nut Steering Gear with a built-in hydraulic assist. This consists of a pump which delivers oil at 750 pounds per square inch, a reservoir, a double-acting hydraulic cylinder, and an ingenious spool-type control valve, as shown in simplified Diagram 1.

The spool valve, part of the steering shaft, is a grooved cylinder machined to a sliding fit within the grooved valve housing. The spool revolves with the steering shaft, can slide forward or backward about .060", and still retain the high-pressure oil. Whenever *less* than three pounds pull on the steering wheel is needed, the valve remains in "neutral" position as shown in Diagram 1, and the circulating oil by-passes the power cylinder. *No hydraulic force whatever is applied to the steering mechanism,* and the car remains completely under manual control. This assures the "feel of the road" SAFETY ZONE which distinguishes Saginaw Power Steering from ordinary types.

However, as soon as *more* than three pounds pull is needed, the resistance of the wheels causes the ball-nut and screw assembly to act as a jack. If the turn is to the *left,* this forces the whole steering shaft, including the valve spool, imperceptibly *toward* the driver as shown in Diagram 2. This changes the course of the oil, so it now flows to the front of the power cylinder and forces the piston backward. Power assistance is thus applied to the pitman arm, to help turn the wheels to the left. At the same time, oil pressure on the valve plungers tends to move the steering shaft and spool back to neutral position, which cuts off the flow of oil to the power cylinder.

When the steering wheel is turned to the *right,* the spool moves slightly *away* from the driver. The oil flows to the opposite end of the power cylinder and forces the piston to assist in turning the front wheels to the right.

The whole system also acts in reverse to resist any force, such as a blowout, which tends to twist the wheel from the driver's hands. When a road shock is transmitted through the pitman arm, the resulting movement of the valve spool admits oil to the proper side of the power cylinder to counteract the shock. Note, too, that a by-pass valve is provided which opens in case of pump failure so there is no resistance to normal manual steering.

IF YOU'D LIKE TO LEARN MORE—we'll be delighted to send you "THE *FACTS* ABOUT POWER STEERING".

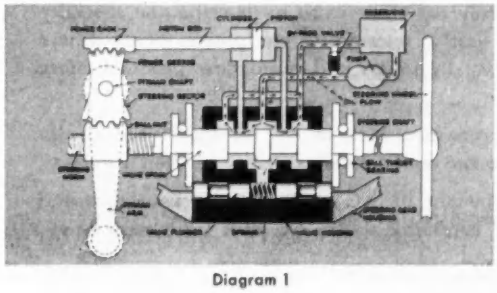

Diagram 1

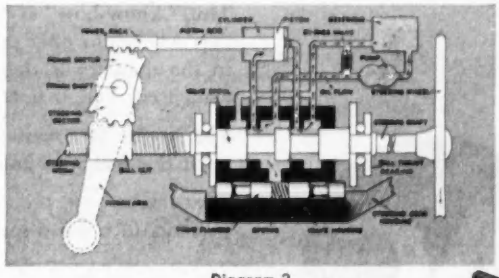

Diagram 2

Saginaw

POWER STEERING

Saginaw Steering Gear Division
General Motors Corporation
Saginaw, Michigan (Dept. J)

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TOP Technical Talent

KNOW-HOW is a relatively new word that Webster defines as "technical expertness and accumulated practical skill in lining up a complicated operation for smooth, efficient execution."

Thus "know-how" is precisely the right word to describe one specialty that AC has to offer every user of automotive equipment. For nowhere in the industry is the ability to design and build new products more evidenced than it is at AC.

That's why 300 manufacturers now look to AC for specialized equipment that helps to improve the quality and salability of their products.

That's why you, too, can benefit by AC's 45 years of experience and vast facilities when seeking a reliable source for your equipment needs.

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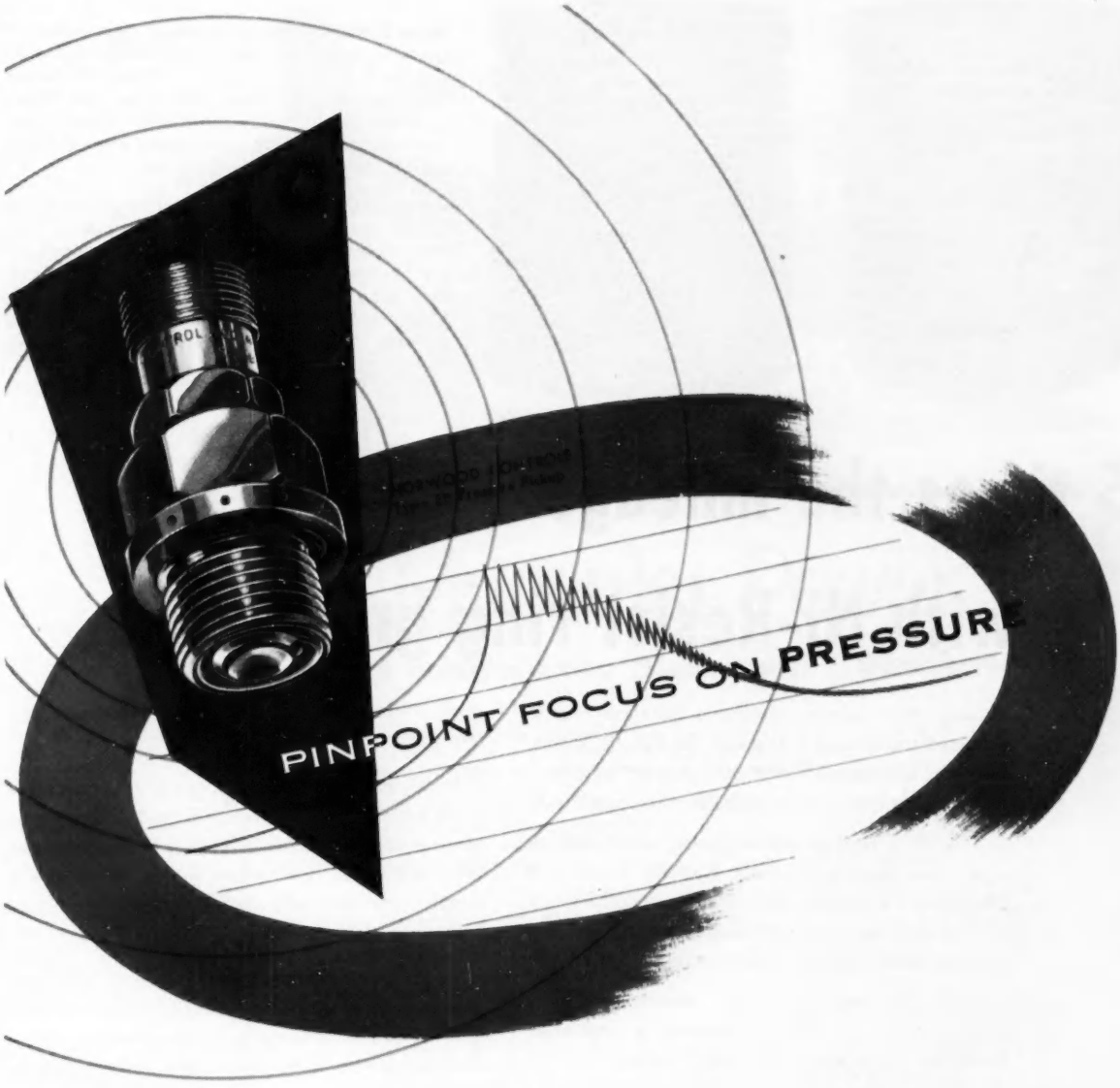
AC SPARK PLUG DIVISION GENERAL MOTORS CORPORATION



Versatility — for use in dynamic systems . . . tested and proven on gasoline and diesel engines . . . jet engines . . . rocket motors . . . blast measurements . . . high pressure, high temperature chemical reactions . . . hydraulic and pneumatic systems.

Full Scale Pressures — 500, 1,000, 2,000, 3,000, 5,000, 10,000 psi . . . response down to 0 psi absolute with 1% of full scale accuracy and temperature compensation.

High Frequency Response — flat to 20,000 cps . . . natural frequency up to 45,000 cps.

Flush Catenary Diaphragm — reduces changes in volume of pressure chamber to a minimum.

A word about NORWOOD CONTROLS—*This name stands for an expanding line of commercial instruments for the measurement of pressure, flow, temperature and weight. It represents a fresh concept of creative engineering which, combined with New England manufacturing skill, is establishing new frontiers in the field of instrumentation.*

NC NORWOOD CONTROLS

CONTROL ENGINEERING CORPORATION
562 Providence Highway, Norwood, Massachusetts

Norwood Controls representatives are located in principal cities.
Complete technical information will be supplied upon request.

After 199,000 miles of service... fleet owner reports "no appreciable wear" on Ni-Resist armored ring band pistons used in Buda Model 844 heavy duty engine. This user, operating 738 Diesel powered freight trucks and trailers in mountainous territory, expects considerably more mileage before replacing pistons of this type.

After 41,078 miles... the top ring groove failed in this conventional-type aluminum piston. Records shown distinct improvements attained by use of armored ring bands of Ni-Resist. Ni-Resist ring bands become an integral part of pistons when bonded to the aluminum alloy by the A1-Fin process, developed by FAIRCHILD ENGINE AND AIRPLANE CORPORATION.

5 times the mileage with Ni-Resist* ring grooves

A large fleet owner, operating gasoline engine powered trucks and trailers in the Rocky Mountain area averages 250,000 miles per set of aluminum pistons with bonded-in Ni-Resist® ring bands.

This is a typical performance, as shown by numerous reports reaching UNITED ENGINE & MACHINE COMPANY, San Leandro, California, a pioneer in producing Ni-Resist armored ring band pistons, sold under the trade-name DUALOY.

Some of these bi-metallic pistons are now in their third 250,000 mile operating runs after being twice reground to the next smaller oversize.

Use of Ni-Resist eliminates ring groove wear troubles. Accordingly, it helps to prevent blow-by and reduces oil consumption. In addition, it resists corrosive attacks from chemically treated fuels. Maximum piston life made possible by using Ni-Resist ring bands results in additional profit from increased mileage between overhauls... and substantial reduction of downtime expense.

Ni-Resist is specified because it combines outstanding resistance to heat, corrosion, metal-to-metal wear and galling. Equally important is the high thermal expansion of Ni-Resist Type 1 which nearly matches that of the aluminum piston alloy.

Other established Ni-Resist engine applications are cylinder liners, valve guides and exhaust system parts.

Investigate Ni-Resist for original equipment parts when designing new heavy duty engines — also for any problems involving corrosion, wear, heat and other destructive forces. We'll gladly supply you with information on the varied uses and types of Ni-Resist.

At the present time, nickel is available for end uses in defense and defense supporting industries. The remainder of the supply is available for some civilian applications and governmental stockpiling.

* *No other cast metal provides such a useful combination of engineering properties.*

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THE INTERNATIONAL NICKEL COMPANY, INC.
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Please send me booklets entitled, "Engineering Properties and Applications of Ni-Resist," and, "Buyers' Guide for Ni-Resist Castings."

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Muscular Power

that controls the McDonnell "Banshee"

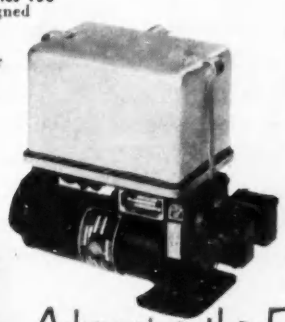
Even before she leaves the deck of a Navy Carrier, her pilot has this swift jet under finger-tip control . . . elevator trim tabs and wing pins moved and positioned by Lear electro-mechanical actuators.

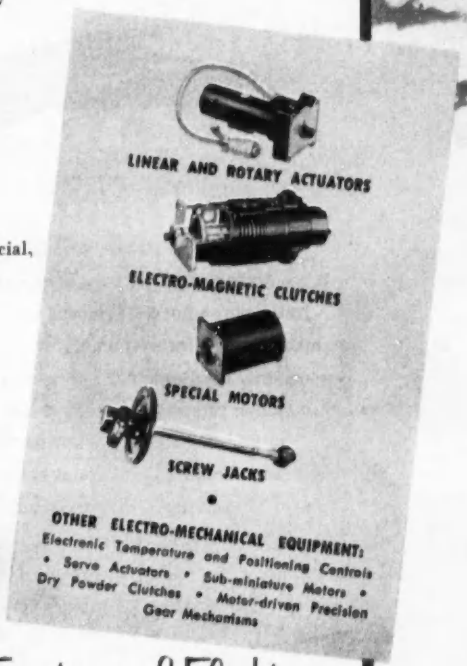
Through Lear drive systems incorporating Screw Jacks, "T" Drives and Flexible Shafting, the Lear Power Unit illustrated transmits the required power.

Engineered to meet the specialized requirements of the "Banshee"... and other well-known aircraft... Lear Control and Actuating Systems provide space-saving power. On the "Banshee" such power is at the pilot's instant command through touch of a button or via automatic controls.

In aircraft large and small, military and commercial, Lear Controls, Actuating Systems and Components are making flight smoother, faster, more economical... and safer.

LEAR POWER UNIT Series 156
Typical of units designed for the McDonnell F2H-2. Specially developed as a power source, produced to meet specific aircraft requirements.

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offers

better careers for engineers

This capacity to develop and produce such a wide range of aircraft is important to career-conscious engineers. It means Lockheed offers you broader scope for your ability. It means there is more opportunity for promotion with so many development and production projects constantly in motion. It means your future is not chained to any particular type of aircraft—because Lockheed is known for leadership in virtually all types of aircraft.

Lockheed's versatility in development and production is also one of the reasons it has an unequaled record of production stability year after year.

1 *Diversified Production*

Huge luxury airliners, cargo transports, fighters, bombers, trainers and radar search planes are rolling off Lockheed assembly lines. Twelve models are in production.

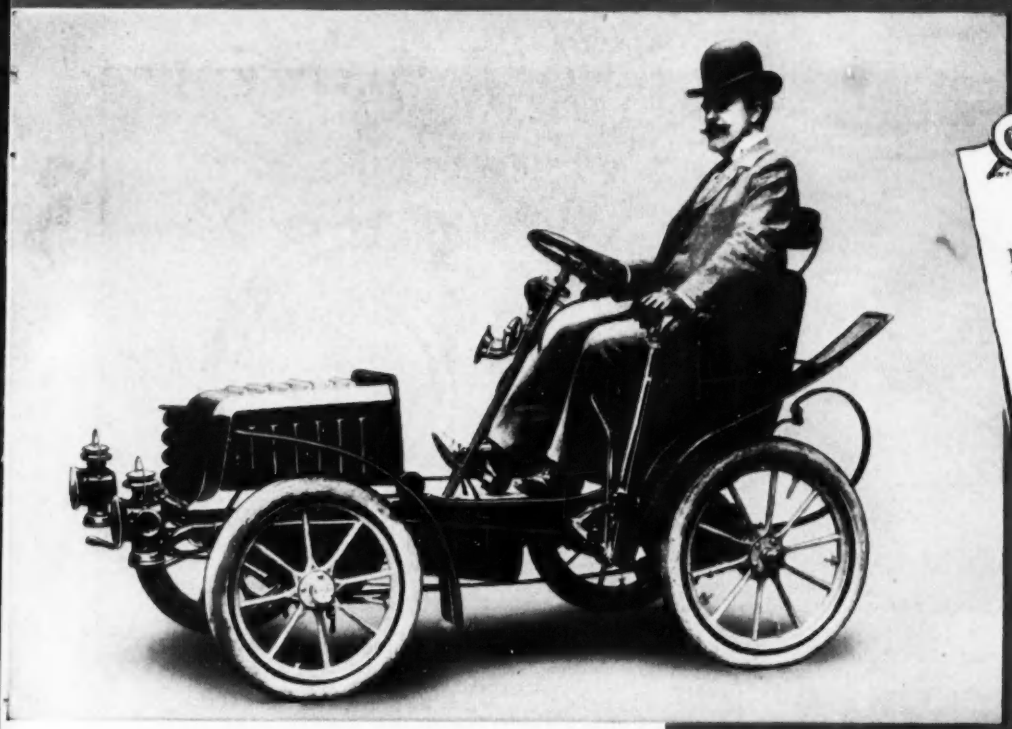
2 *Diversified Development Projects*

The most diversified development program in Lockheed's history is under way—and it is still growing. The many types of aircraft now in development indicate Lockheed's production in the future will be as versatile as it is today—and has been in the past.

3 *Diversified Living*

You work better in Lockheed's atmosphere of vigorous, progressive thinking—and you live better in Southern California. You enjoy life to the full in a climate beyond compare, in an area abounding in recreational opportunities for you and your family.

Lockheed AIRCRAFT CORPORATION
Burbank, California



Send for free print

1900 Vinet, a forerunner of later French "economy cars," was built around a vertical two-cylinder motor delivering five and one-half hp. Novel transmission feature: "speed-change gear" of two trains of loose wheels operating off a two-guide hand lever.

This is one of a series of antique automobile prints that will appear in future Morse advertisements. Write for your free, enlarged copy, suitable for framing.

The Bettmann Archive

Tested and established advantages won industrywide acceptance for Morse Timing Chain Drives . . . made M=TC an automotive *byword* . . . can benefit you with savings, technical help, better delivery.

Advantages? Morse Timing Chain Drives maintain accurate, positive timing despite shaft end-play . . . assure safe, quiet performance even when camshafts and crankshafts are not exactly parallel . . . you realize production savings through greater permissible engine block tolerances, greatly increased ease of assembly.

Engineers? Many an engineer has learned to welcome the solid help of Morse specialists, who thrive on tough design, development, application problems.

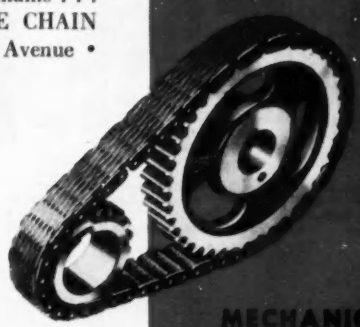
Benefit you? You can count on the same longer-lived dependability, economy, customer-conscious delivery that've led makers of eleven of the thirteen cars now using timing chain drives to use Morse Timing Chain Drives as original equipment.

Call or write us for information on *your* timing-chain problems. It won't take much of your time to see *why* M=TC; Morse *means* Timing Chains . . . and *how* this can benefit you. MORSE CHAIN COMPANY • Dept. 517 • 7601 Central Avenue • Detroit 10, Michigan.

The advantages that can benefit you made an automotive byword of this equation:

M=TC

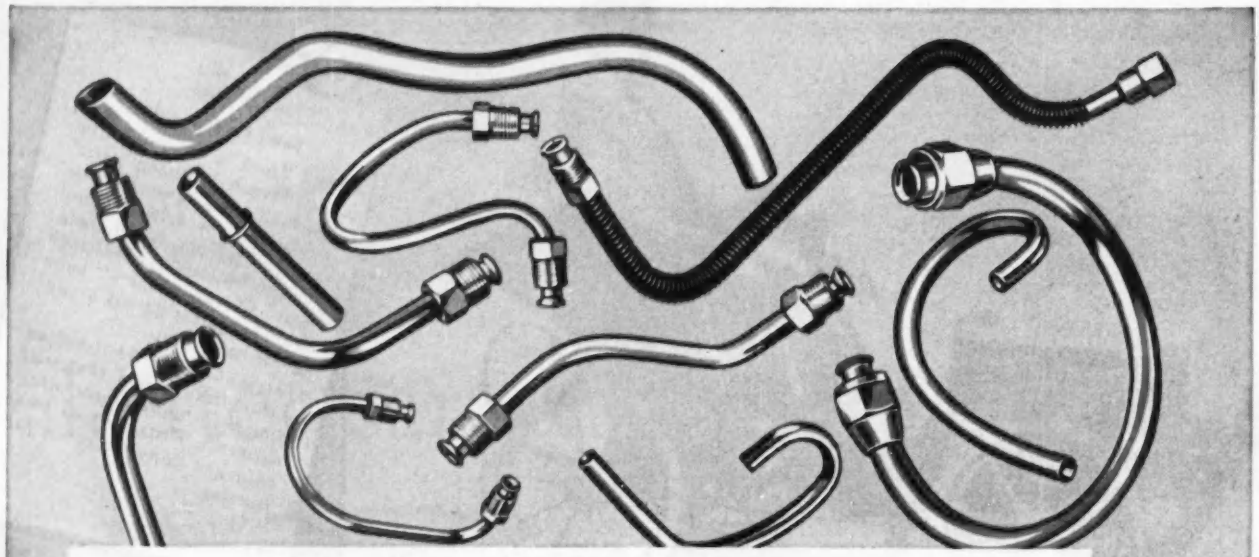
Morse *means* Timing Chains



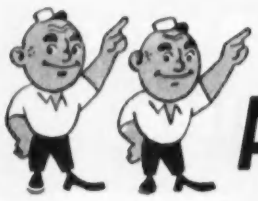
MORSE

PRODUCTS OF BW BORG-WARNER

MECHANICAL POWER TRANSMISSION PRODUCTS



Here is a small sampling of the variety of parts produced for Bundy automotive customers. Many of them involved close cooperation between Bundy engineers and the customers in solving problems of design and function. Are your tubing designs simple or complex? Do they call for swaging, flattening, expanding, brazing, saddle jointing, bending to small radii, piercing, upsetting, slotting, threading, angle cutting, notching, flanging, flaring, reducing, tapering, other fabrication operations, or combinations of the above? Come to Bundy for the automotive industry's most reliable tubing, most helpful engineering talents, and most versatile fabrication facilities.



Almost no limit to what we can do for you with Bundyweld Tubing

WHY BUNDYWELD IS BETTER TUBING

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

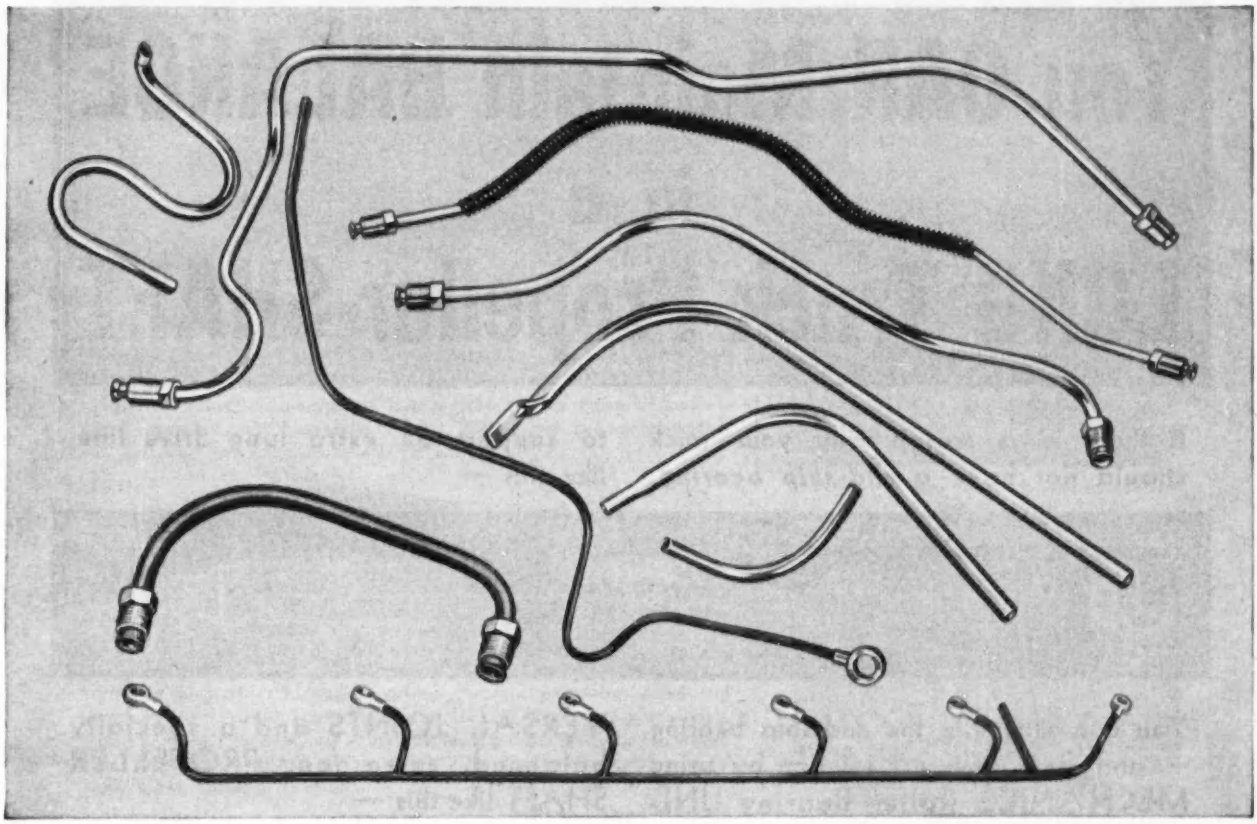
continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

← **NOTE** the exclusive patented Bundyweld beveled edges, which afford a smoother joint, absence of bead and less chance for any leakage.

Bundy Tubing Distributors and Representatives: *Cambridge 42, Mass.:* Austin-Hastings Co., Inc., 226 Binney St. • *Chattanooga 2, Tenn.:* Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • *Chicago 32, Ill.:* Lapham-Hickey Co., 3333 W. 47th Place • *Elizabeth, New Jersey:* A. B. Murray Co., Inc., Post Office Box 476 • *Philadelphia 3, Penn.* Rutan & Co., 1717 Sansom St. • *San Francisco 10, Calif.:* Pacific Metals Co., Ltd., 3100 19th St. • *Seattle 4, Wash.:* Eagle Metals Co., 4755 First Ave. South *Toronto 5, Ontario, Canada:* Alloy Metal Sales, Ltd., 181 Fleet St., East • **Bundyweld nickel and Monel tubing is sold by distributors of nickel and nickel alloys in principal cities.**



It almost goes without saying that you can't beat Bundyweld for leak-proof, dependable performance in your brake, oil, and gasoline lines and in other tubing lines throughout your cars, trucks, or tractors.

But you get more than peace of mind with Bundyweld. For instance, you tap a wealth of fabrication facilities and engineering skills.

Do your tubing part designs call for difficult fabrication operations or easy ones? Do the designs call for unusual combinations of operations? Do they create problems that may seem unsolvable?

If your needs call for a tubing part that is at all produceable, you can count on us to do the job—exactly to specifications at lowest possible cost to your company. But say it isn't produceable. What then?

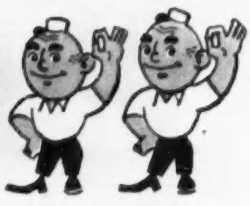
Just this. Bundy engineers who know their Bundyweld and automotive tubing problems inside and out will work with you personally until problems turn into solutions. This help and teamwork pay off in time and trouble saved. And such a pooling of specialized skills—yours and the Bundy man's—frequently pays off in lowered material costs and lowered production costs, too.

What if *your* company is geared for low-cost fabrication? Wonderful. You can count on us to ship clean, carefully inspected Bundyweld on time and in specified straight lengths. Of course, you can still summon all the engineering help you can use.

For tubing that's the standard of dependability, for fabrication facilities and engineering talents devoted to producing better parts at lowest possible cost, come to headquarters for small diameter tubing.

BUNDY TUBING COMPANY
DETROIT 14, MICHIGAN

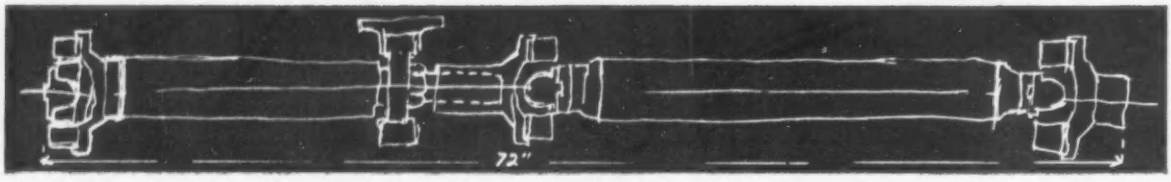
Bundyweld® Tubing



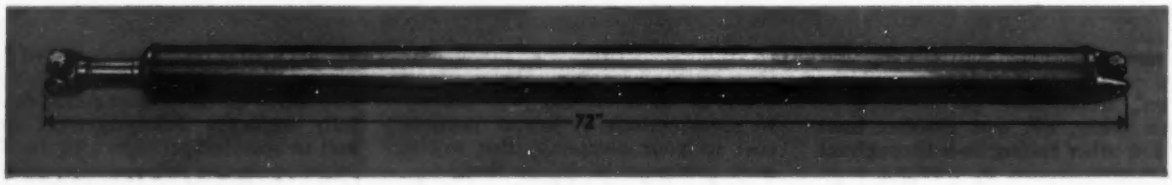
DOUBLE-WALLED FROM A SINGLE STRIP

You CAN Maintain BALANCE in a LONG Truck Propeller SHAFT

If there is a reason why *your* truck should not have a *mid-ship bearing,* to support an extra long drive line, like this —



You can eliminate the mid-ship bearing — and one universal joint — by using MECHANICS Roller Bearing UNIVERSAL JOINTS and a specially balanced, *extra long* PROPELLER SHAFT like this —



MECHANICS engineers constantly are solving joint and propeller shaft problems. Let them contribute their extensive experience toward making *your* truck or heavy duty equipment *drive lines* more effective.

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2022 Harrison Avenue, Rockford, Illinois

MECHANICS
Roller Bearing BW
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

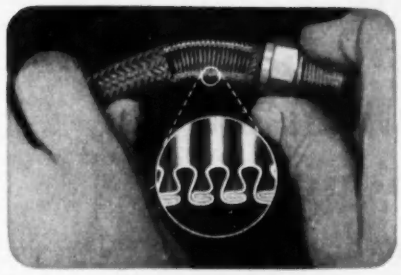
EXPANSION-CONTRACTION-VIBRATION...

Here are 3 Ways to Cure Them!

These are the right connections—wherever there's *unwanted motion* —or critical temperature, pressure, vacuum or corrosive action.

TITEFLEX®
All-Metal
Flexible Hose

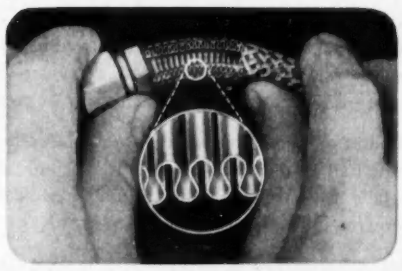
stands up to conditions that would ruin rigid tubing. You can use it for scores of ticklish jobs . . . Connect misaligned or moving parts of machinery. Absorb vibration, or pulsation. Transmit vacuums, shield wires and cables against electrical or electronic interference. Handle difficult gases, vapors or liquids—from ammonia to acid to sea-water to steam. There's more than one application in your plant *right now* that needs TITEFLEX.



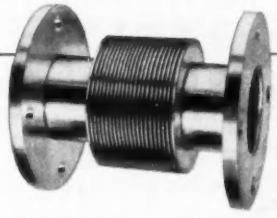
Sectional view shows rugged, flexible, seamed construction of Titeflex.

UNIFLEX
Helically-Corrugated
Seamless Flexible Tube

is tough, corrosion-resistant, leakproof. Use it in applications too tough for ordinary concentric tubing. For example, oil burners, hydraulic lines, air conditioning equipment, refrigeration machinery, pumps, compressors, diesels and machine tools. Metal-to-metal seat of UNIFLEX fittings assures leakless service. Helical, seamless wall structure gives it greater flexibility and longer life. Thoroughly tested in service, UNIFLEX offers real advantages where conventional tubing gives trouble.

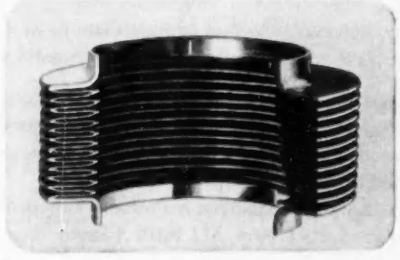


Note the helically-corrugated, seamless wall structure of Uniflex.



TITEFLEX BELLOWS

have unique, welded, convoluted-diaphragm construction. They absorb lineal movement in many types of equipment—*without* weakening lines and without reducing the flow rates of gases or liquids being conveyed. Use TITEFLEX Bellows to accommodate lineal contraction and expansion or high frequency vibration, to seal high pressure valves and shafts, or to handle gases and corrosive liquids at high temperatures. For special applications, special designs can be furnished. Complete bellows assemblies can be supplied with any required types of fittings.



Cross-section shows the welded, convoluted-diaphragm construction of Titeflex Bellows.

FOR FREE LITERATURE check the products (below) that interest you and mail the coupon. By return mail we'll send you current TITEFLEX literature, containing full descriptions, technical data and suggestions for use. Also, if you have a specific problem, our Engineering Staff will be glad to discuss it with you without obligation.

Let Our Family of Products Help Yours

Titeflex

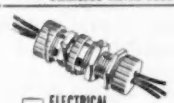
✓ Check products you are interested in.

☐ SEAMED AND SEAMLESS METAL HOSE

☐ PRECISION BELLOWS

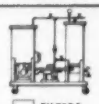
☐ IGNITION HARNESS

☐ IGNITION SHIELDING



☐ ELECTRICAL CONNECTORS

☐ RIGID AND FLEXIBLE WAVE GUIDES



☐ FILTERS

☐ FUSES

TITEFLEX, INC.
516 Frelinghuysen Ave.
Newark 5, N.J.

Please send me without cost information about the products checked at the left.

MAIL COUPON TODAY

NAME _____

TITLE _____

FIRM _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

NOW... replace dull tools without halting production!

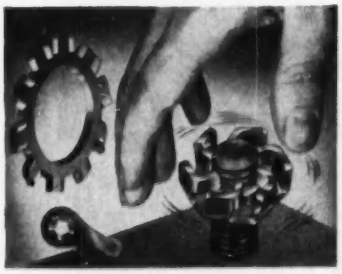
AMF WAHLSTROM Instant-Change Chucks provide the Automotive Industry a unique way to save time!

Drills, reamers and similar tools are removed and replaced *instantly* ... without keys, collets or wrenches ... without even slowing the spindle—thanks to the AMF Wahlstrom Instant-Change Chuck.

A slight hand pressure causes the powerful, self-centering jaws to release the tool, or lock it in place. And this unique chuck cannot chew up shanks; so tools *last longer* and continue to do precision work.

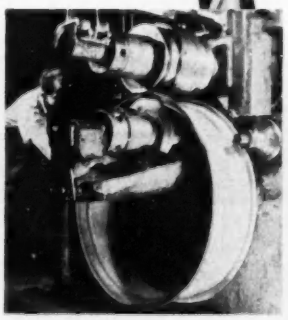
The AMF Wahlstrom Fully-Automatic, Instant-Change Chuck has been widely used for years on drill presses, boring mills, milling machines and lathes, permitting a single spindle to perform a wide variety of consecutive operations. The Automotive Industry, however, was first to appreciate its time-saving possibilities in replacing dull tools on large-scale operations.

This is but one example of how engineering ingenuity and AMF products help the Automotive Industry produce *better* products ... faster ... at lower cost! Others are illustrated below. Your inquiries are invited.
Address: American Machine & Foundry Company, General Products Group, 511 Fifth Avenue, New York 17, N.Y.



ASSEMBLY IS SPEEDED by AMF's Thompson-Bremer *Everlock** self-locking nuts, tooth-type lock washers and sems.

SHIPPING AND MAINTENANCE departments find AMF De Walt* Power Saws save time in all wood-cutting operations.

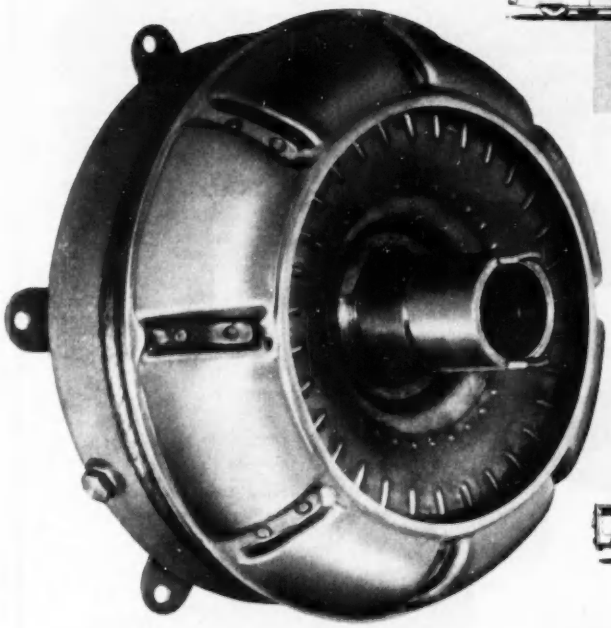


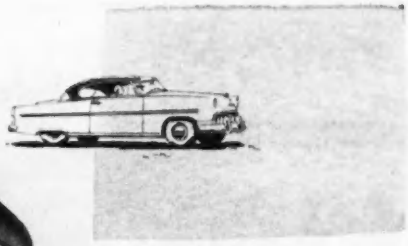
MAJOR SUPPLIER of rims and circular weldments for the Automotive Industry is AMF's Cleveland Welding Company.

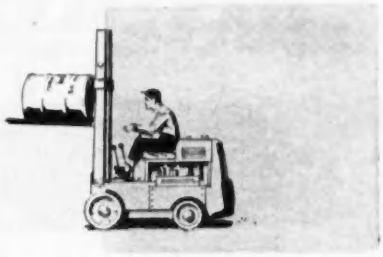
AMF INDUSTRIAL LOWERATOR* DISPENSERS store and position planned quantities of parts in process at efficient working levels.

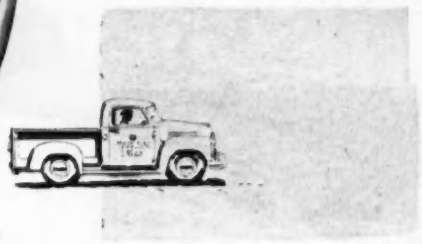
amf products ARE BETTER ... *by design*
AMERICAN MACHINE & FOUNDRY COMPANY

*Registered Trademark









The LONG TORQUE CONVERTER is in Volume Production for...

- **INDUSTRIAL MATERIALS HANDLING TRUCKS**
- **AUTOMOBILES**

The Long Torque Converter provides smoother, faster, more economical operation for industrial trucks. Combined with a hydraulically-operated clutch it provides even greater flexibility in use.

Available in 11- and 12-inch diameters, for engines ranging from 90- to 200-lbs-feet torque, the Long design is easily modified for a wide variety of other applications. Its design, incorporating use of economical stampings and leakproof welding, assures *low* cost.

To prospective users of converters in these capacities, we offer low cost production and our complete engineering cooperation.

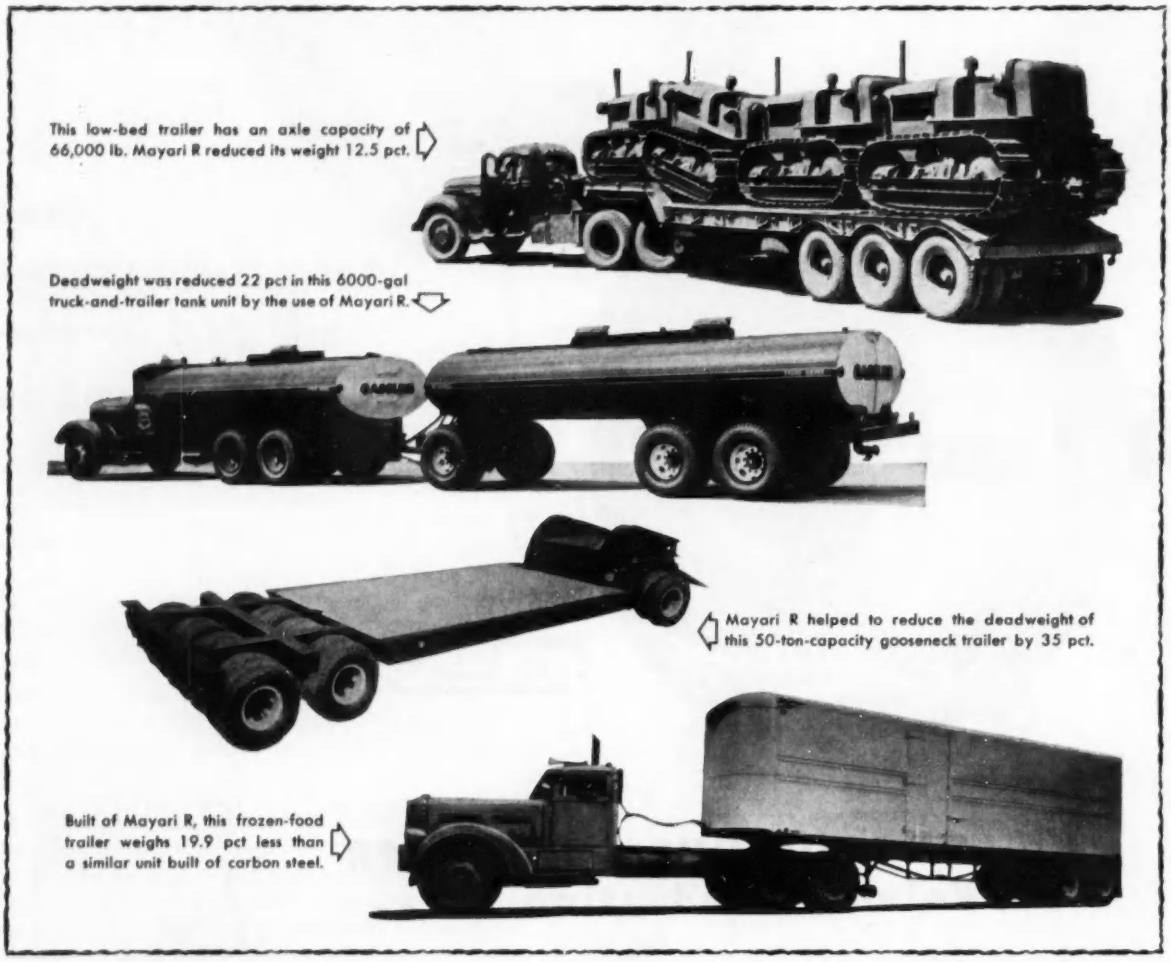
LONG MANUFACTURING DIVISION • BORG-WARNER CORPORATION
DETROIT, MICH. AND WINDSOR, ONT.

50 Years
of Quality Manufacturing for the Automotive Industry

LONG

BW

TORQUE CONVERTERS • CLUTCHES • RADIATORS • • OIL COOLERS


This low-bed trailer has an axle capacity of 66,000 lb. Mayari R reduced its weight 12.5 pct.
Deadweight was reduced 22 pct in this 6000-gal truck-and-trailer tank unit by the use of Mayari R.
Mayari R helped to reduce the deadweight of this 50-ton-capacity gooseneck trailer by 35 pct.
Built of Mayari R, this frozen-food trailer weighs 19.9 pct less than a similar unit built of carbon steel.

WHAT IS IT WORTH TO ADD 20% TO PAYLOAD CAPACITY?

How much do you think it would add to the value of a truck, trailer, or tanker to decrease its deadweight by 20 pct, and increase its carrying capacity by an equal amount?

This can be done readily, without exceeding the legal axle-load limits. And it can be done economically, by designing a vehicle to be built of Mayari R low-alloy, high-strength steel.

Yes, Mayari R does cost more than carbon steel—but it takes less of it to do the job. It can be used in thinner sections because it has a yield point almost double that of plain carbon steel, and it has from 5 to 6 times as much resistance to atmospheric corrosion. It retains paint 20 pct to 80 pct longer, depending upon the type used. Also, it can be fabricated and welded by the same methods and with the same equipment that are ordinarily used for carbon steel.

If you would like more information on the properties and advantages of this superior grade of steel, write or phone for Mayari R Catalog 259.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

Mayari R *makes it lighter... stronger... longer lasting*

the chilled-iron face gives Eaton Tappets superior load-carrying capacity and longer life

To keep pace with the requirements of today's higher-speed, higher-compression engines, Eaton has developed special foundry facilities to produce chilled-face tappets with essential hardness and wear-resistant characteristics. Eaton offers volume-produced, volume-priced, lightweight tappets capable of carrying excessively high loads. From the ladle to final inspection, the wear-resistant hardness of the face and the over-all quality of Eaton tappets are guarded by precise metallurgical control.

EATON MANUFACTURING COMPANY

General Offices: CLEVELAND, OHIO

SAGINAW DIVISION: 9771 FRENCH ROAD • DETROIT 13, MICHIGAN

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

Bendix automotive Electric Fuel Pump

Prevents Vapor Lock

Result

- **better performance**
- **better gas mileage**
- **reduced service expense**

Today it's more important than ever that car and truck manufacturers take every precaution to prevent vapor lock in their vehicles. Modern design and more volatile gasoline contribute immeasurably to increased power and speed; but in achieving these desirable goals heat problems are sometimes increased to the point where vapor lock occurs. Then, gas mileage is reduced, gains in power and speed are nullified, and worst of all, if vapor lock occurs frequently, exhaust valves burn out and expensive overhauls are necessary.

Fortunately car and truck manufacturers can now guard against this hazard. By installing Bendix* Electric Fuel Pumps, vapor lock can positively be prevented and the efficient performance built into the vehicle will be delivered under every operating condition.

In today's competitive market, here is small investment that will pay big dividends in increased customer satisfaction. Descriptive folder available on request.

*REG. U.S. PAT. OFF.

Check these Features

- Prevents vapor lock.
- Built-in pressure release—no flooding.
- Instant hot weather re-starts.
- 30 gallons per hour.
- Helium sealed—for longest life.
- Better cold weather starting.
- Only 7 watts power at maximum fuel delivery.

ECLIPSE MACHINE DIVISION

Elmira, New York · *Division of* Bendix AVIATION CORPORATION

1903 1953
FIRST FIFTY YEARS
CLARK EQUIPMENT

CLARK

This unique housing—a one-piece, heat-treated forging—is one of the most widely used commercial axle housings. It is the result of seasoned, resourceful Clark engineering—which for you can mean substantial, product-improving benefits. It's good business to work with Clark.

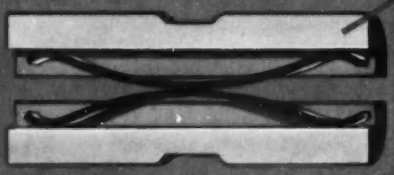
Turn and see reverse side for more about CLARK products

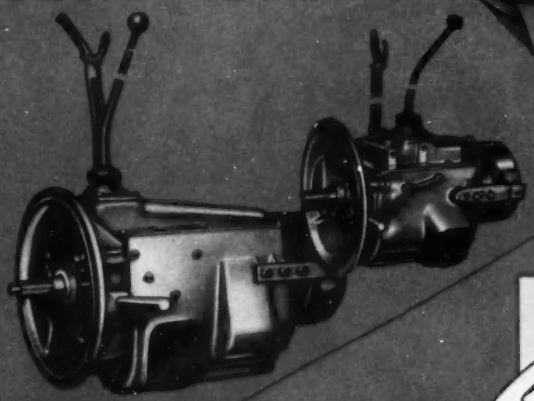
CLARK EQUIPMENT COMPANY, Buchanan, Michigan

Other Plants: BATTLE CREEK AND JACKSON, MICHIGAN

THE New CLARK Split-Pin SYNCHRONIZER

CLARK transmissions are now available featuring THE "SPLIT-PIN" SYNCHRONIZER. In keeping with its traditional enthusiasm for engineering development, Clark not only builds a full range of conventional models, but specializes in designing and producing transmissions for unusual requirements for trucks, busses, farm tractors, industrial trucks and road building machinery.





1903 1953 CLARK EQUIPMENT

Write for Products Booklet.

How much did OBSOLESCENCE COST YOU TODAY?

THE FASTEST WAY for any machine to become obsolete is for someone to develop a new machine to do the same job faster, better, and more economically. That applies to fork trucks—and when it comes to constant efforts to improve our product, CLARK pleads guilty.

You owe it to yourself to know What's New (and better!) in industrial trucks. Why not let your Clark dealer give you proof?—proof that a carefully-planned modernization program will improve production and cut service costs so drastically that it will soon pay for itself.

Write for Material Handling News.

CLARK EQUIPMENT *Products*— TRANSMISSIONS • AXLE HOUSINGS • GEARS and FORGINGS • TRACTOR UNITS • FORK TRUCKS and TOWING TRACTORS • FRONT and REAR AXLES for TRUCKS and BUSSES

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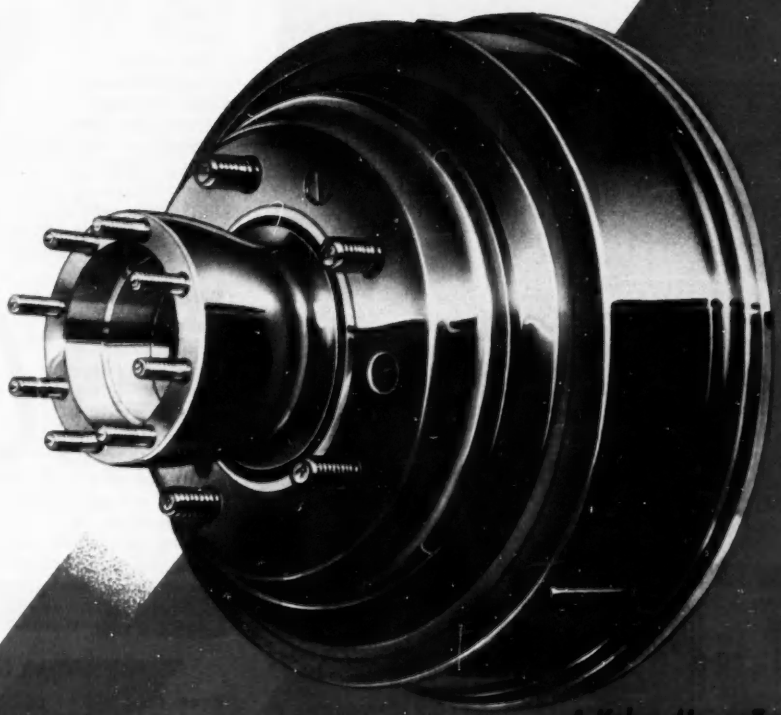

A Kelsey-Hayes Truck Hub and Brake Drum Assembly

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NATIONAL OIL SEAL LOGBOOK

Write our Redwood City office for reprints of this Logbook page

Sealing News & Tips

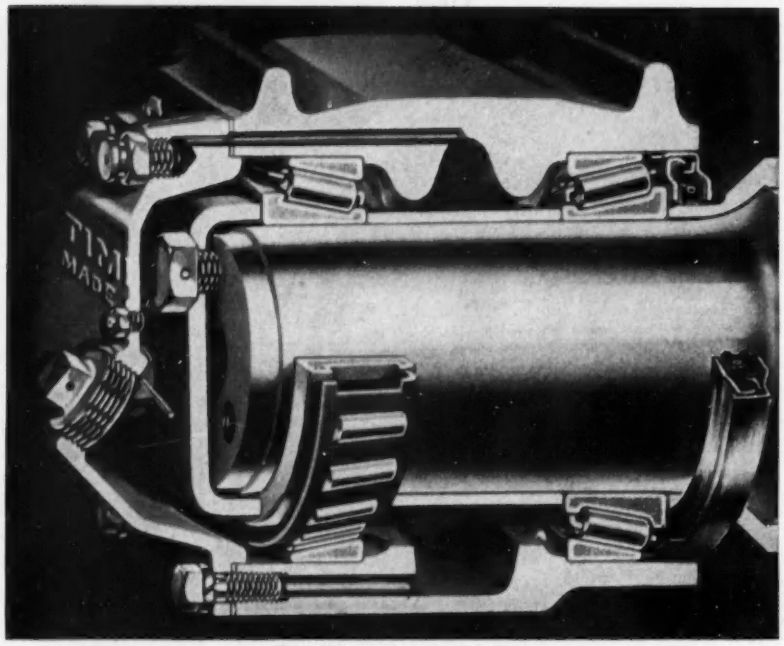

Fig. 1. Timken railway journal box

Special convoluted dual lip Syntech* seal designed for Timken railway roller bearing

Timken cartridge-type journal boxes for roller freight cars (Figure 1) employ a National Syntech seal to retain light bearing grease and exclude dirt, dust and water. This seal (Figure 2) has a convoluted sealing member of National Syntech (synthetic rubber), incorporating two opposed sealing lips tensioned by a middle-positioned spring. This design, plus the natural flex action of Syntech, insures uniform sealing under all operating conditions.

For maximum rigidity, durability and dimensional uniformity, the sealing lip is bonded to a steel member and assembled within a steel outer case. The case press fits into the Timken cartridge housing. A special requirement of the application is that the outer sealing lip must run dry on a 6.3" shaft, at speeds up to 1,000 r.p.m. A modified Syntech compound proves satisfactory for this demanding application.

National seals used in Timken railway bearing applications are specially designed to meet special conditions. In many sealing applications, however, one of 2,500 standard-design National Oil Seals can often be utilized. In either case, National Applications Engineers are at your service. Their special skills are backed up by the world's largest manufacturing facilities devoted exclusively to seals and 30 years of practical sealing experience.

Fig. 2. National Syntech Seal

*T. M. Reg.

National 50,000-S Syntech Seal

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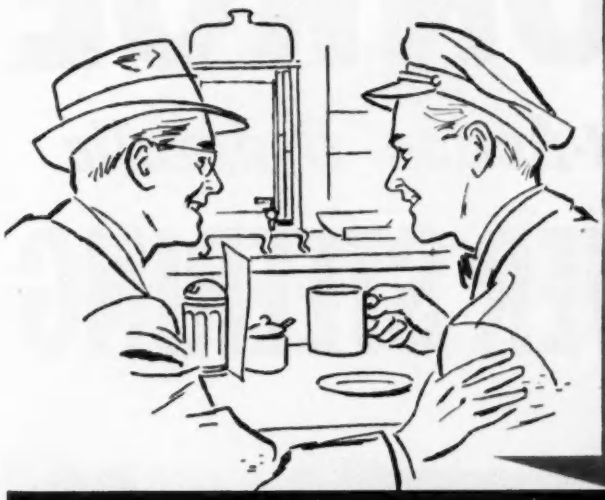
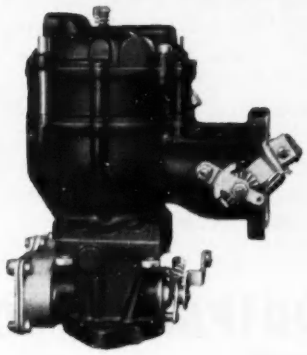
Does He Knock or Boost Your Truck?



IT ALL DEPENDS ON PERFORMANCE and PERFORMANCE DEPENDS ON

Zenith CARBURETORS



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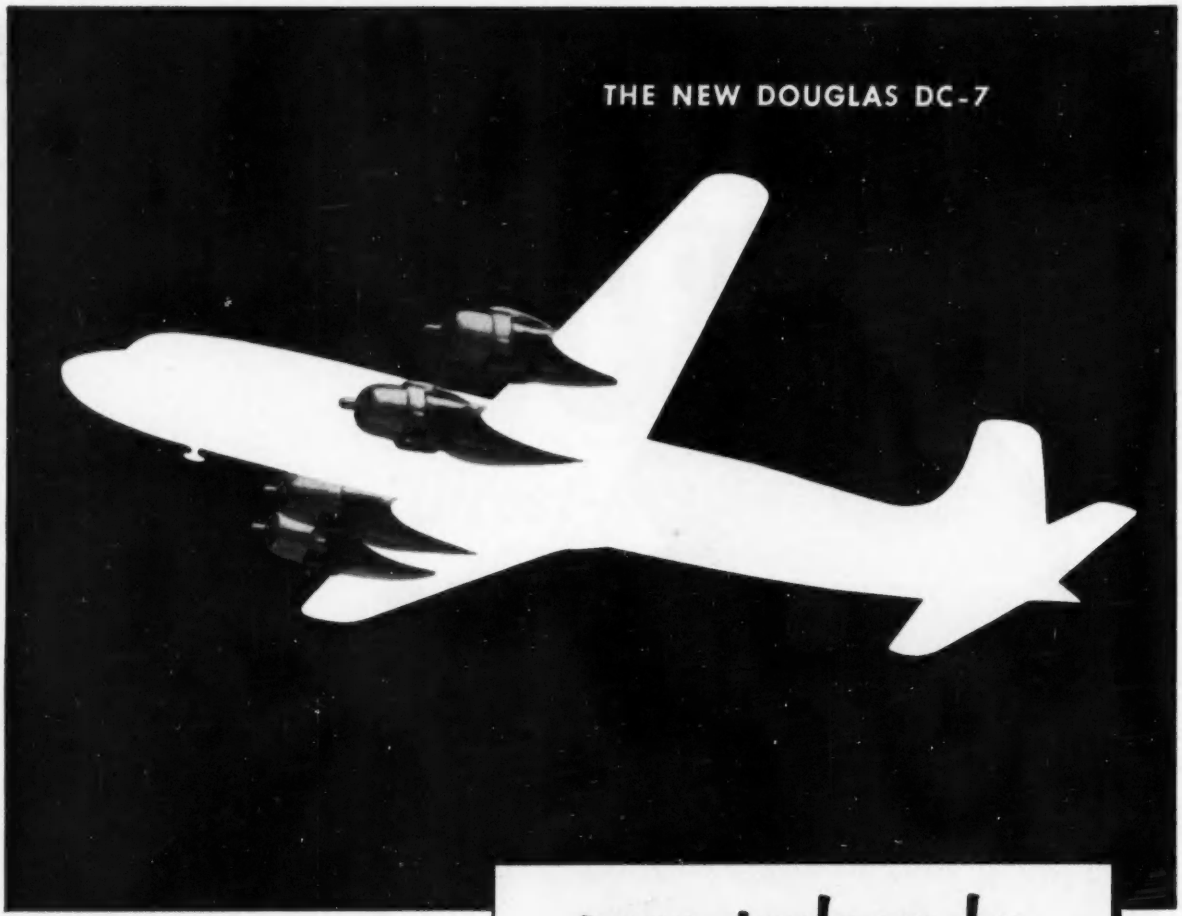
THE NEW DOUGLAS DC-7



Here's the big, handsome, DC-7 – Douglas' latest commercial airplane. This picture shows off the power packages built for the DC-7 by Rohr... world's largest producer of ready-to-install power packages for both commercial and military planes. In addition, Rohr Aircraftsmen currently are producing more than 25,000 different parts for all types of airplanes.

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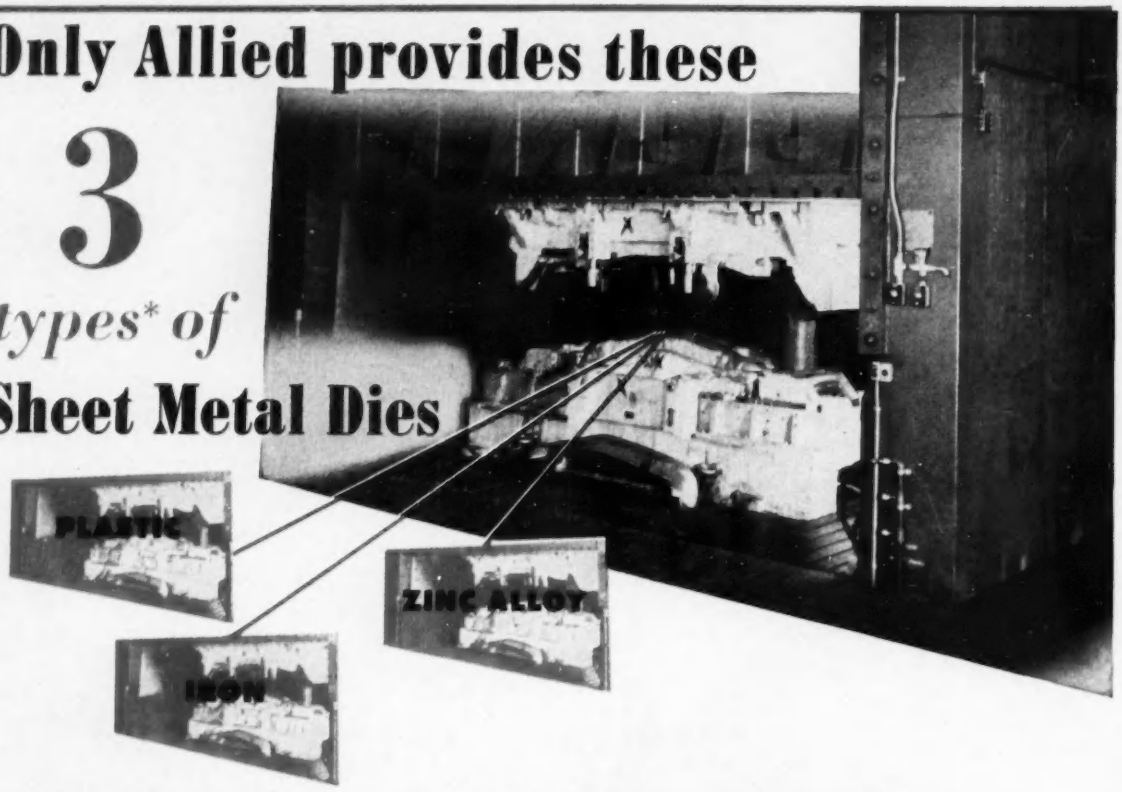

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PLANT 2
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PLANT 3
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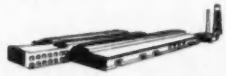

PLANT 4
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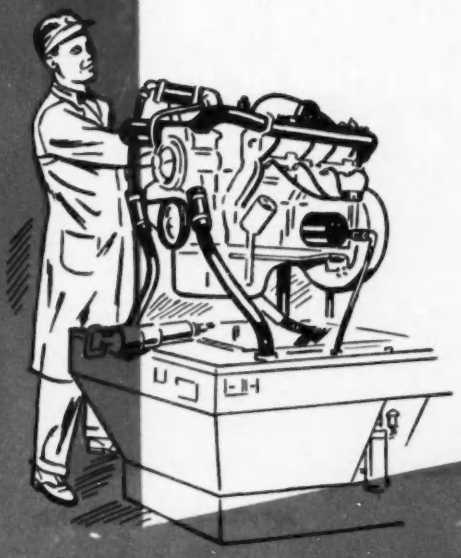

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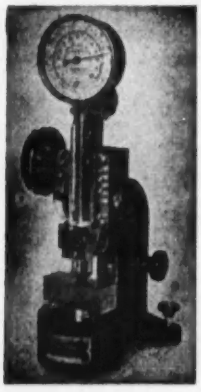

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new...

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This SAE Recommended Practice is the most recent addition to the SAE data on suspension problems and vibrating systems.

The new SP-6b is to appear in the 1953 edition of the SAE Handbook.

The work of the SAE Riding Comfort Research Technical Committee, it received full approval in July 1952. 50¢ to members; $1.00 to non-members.

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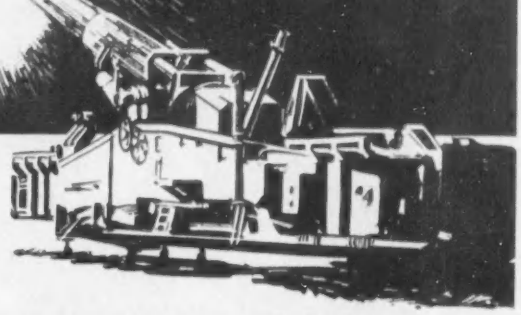
of 280 mm atomic gun barrel



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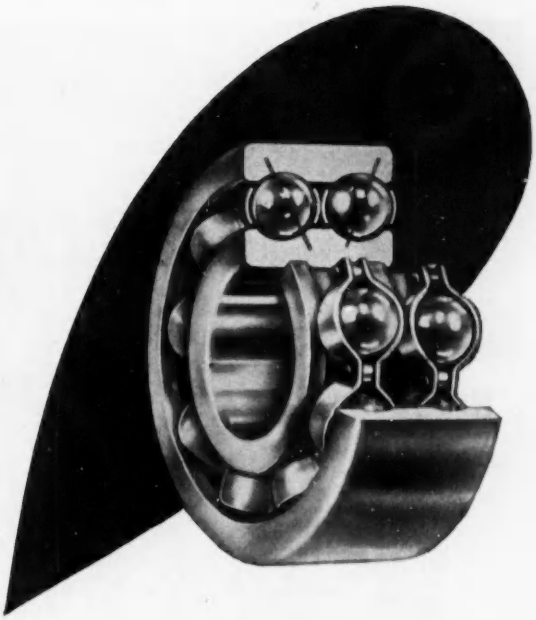
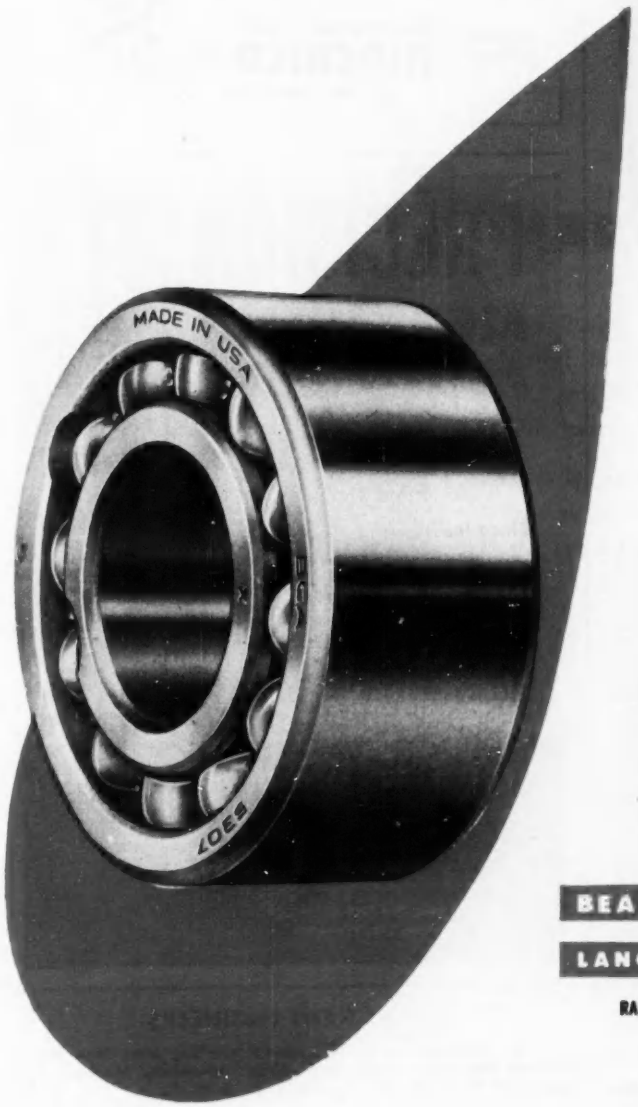
BCA 5200 and 5300 SERIES BEARINGS

can carry any combination of radial and thrust loads





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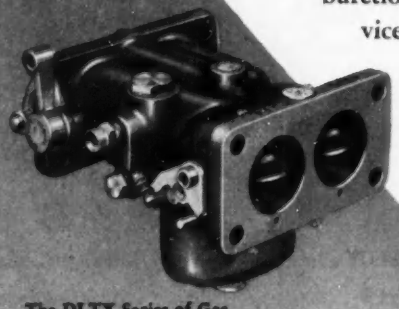
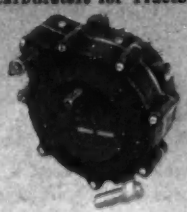
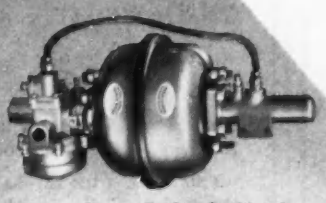


The DLTX Series of Gas Carburetors for Tractors



LP Gas Carburetion Systems for Truck and Tractor Conversion



Power Brakes for Trucks

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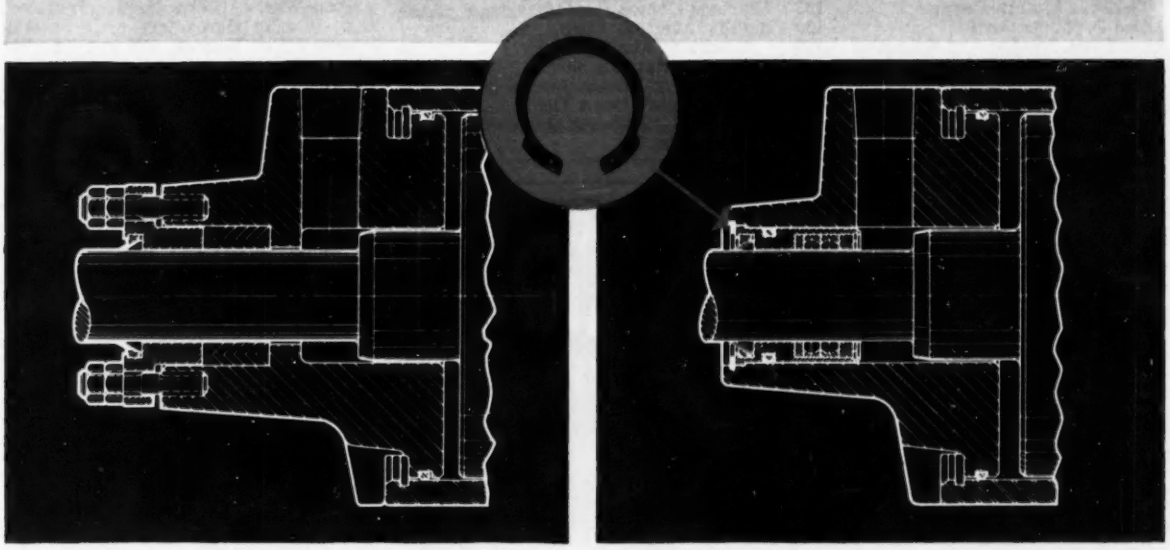

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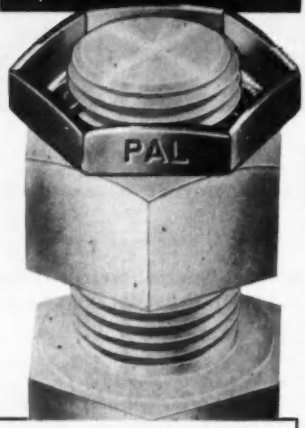

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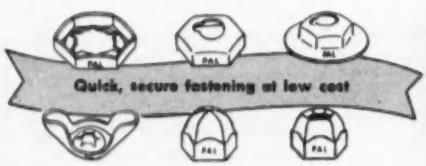

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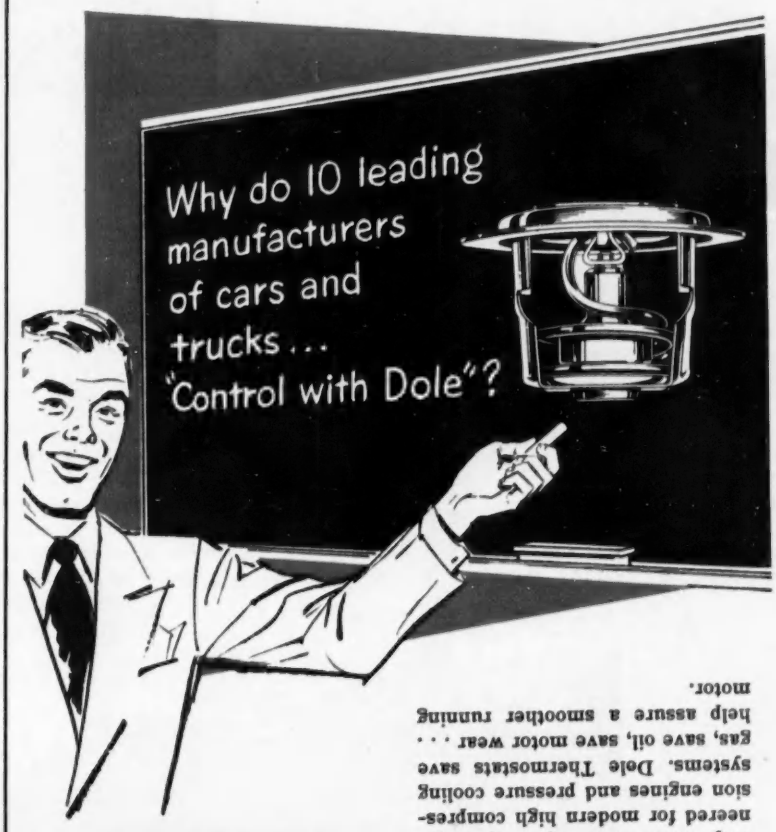

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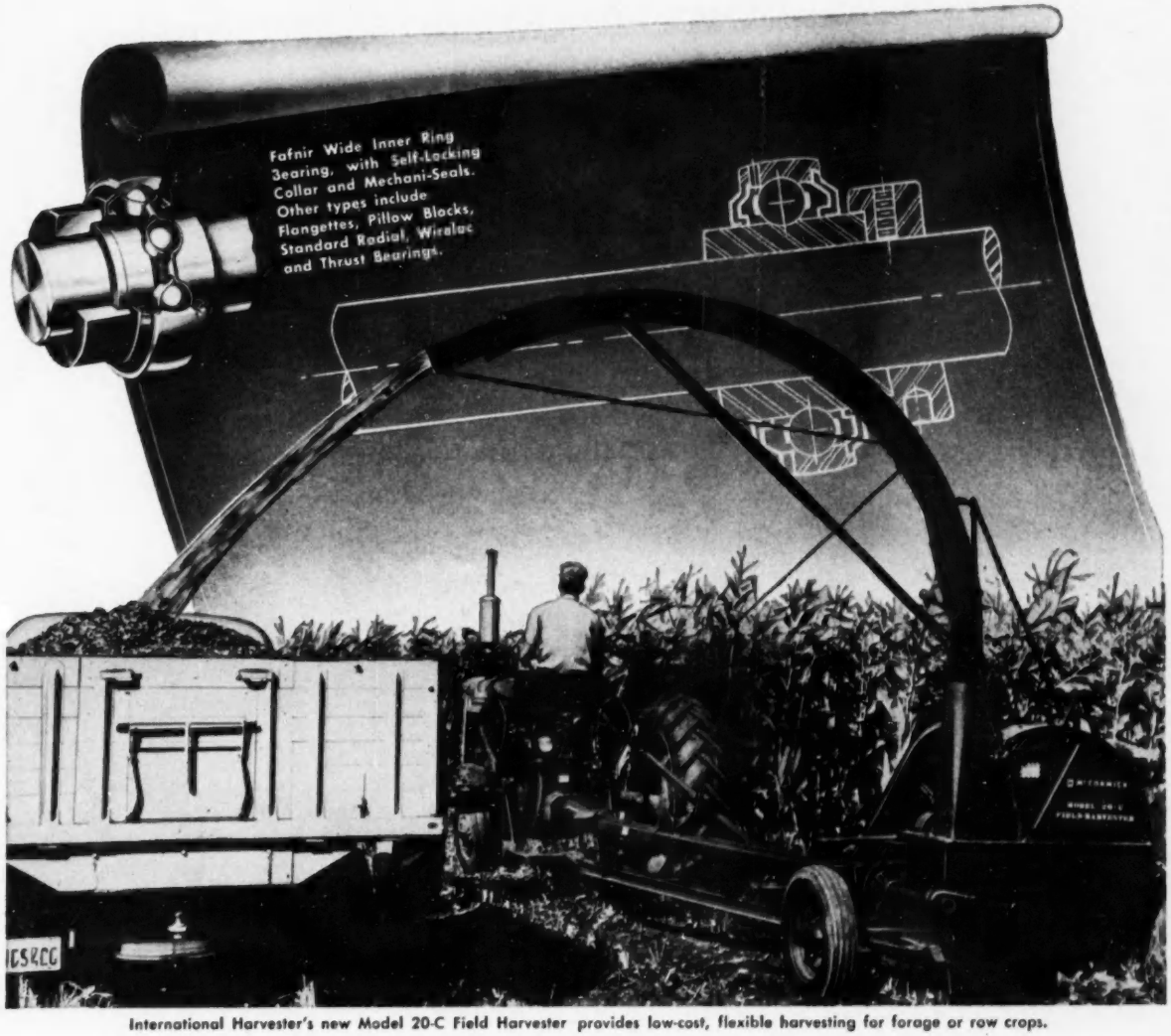

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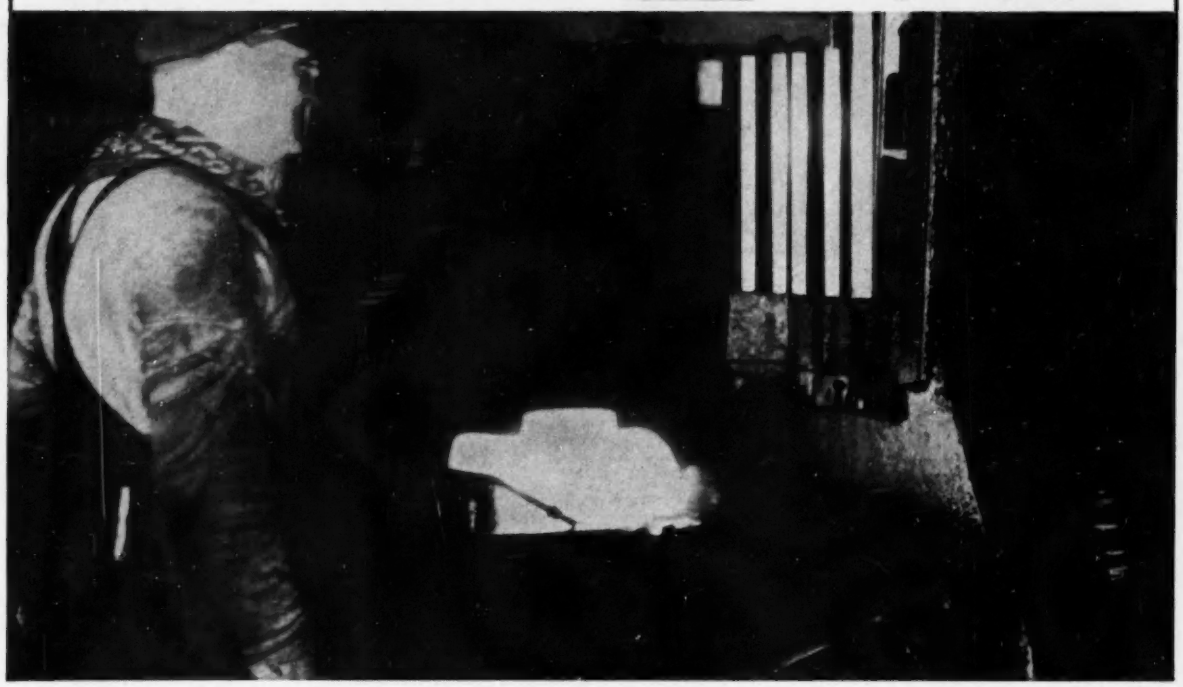

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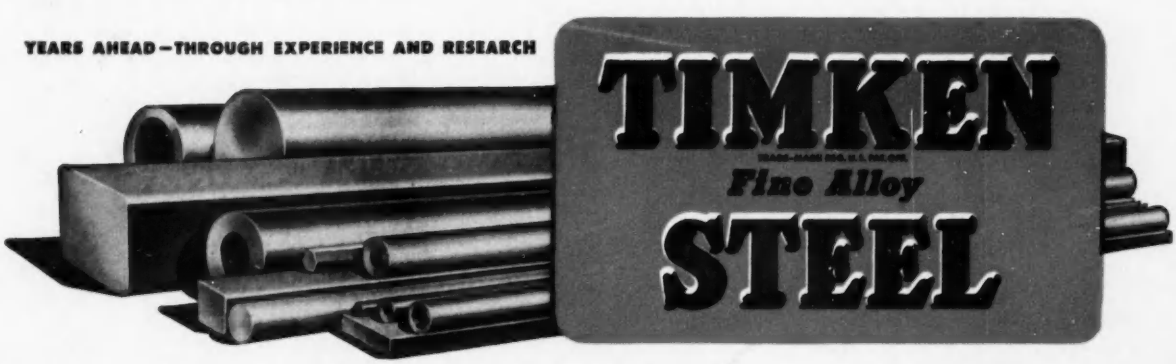

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